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A NOVEL, STRAIN LIMITED, UNI- & BIAXIAL DESIGN METHOD FOR CONCRETE ENCASED STEEL COMPOSITE COLUMNS WITH NORMAL AND HIGH STRENGTH STEEL AND CONCRETE

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ABSTRACT

A NOVEL, STRAIN LIMITED, UNI- & BIAXIAL DESIGN METHOD FOR CONCRETE ENCASED STEEL COMPOSITE COLUMNS WITH NORMAL AND HIGH STRENGTH STEEL AND CONCRETE

In this study, a novel design method for concrete encased steel sections having normal and high strength concrete and steel is presented. The proposed method develops around strain limitation principle as opposed to plastic section assumption. It extends current Eurocode 4's simplified method's material strength limitations to C90/105 for concrete and S550 for steel, proposes a new equation for equivalent second order flexural stiffness to calculate internal bending moments considering an initial bow imperfection value of L/400. Proposed design method enables to conservatively convert a fully plastic interaction diagram to a strain limited one depending on material resistances on the column. Finally, an analytical equation is presented to develop biaxial interaction surfaces from interaction curves about principal axes. The proposed equation allows for accurate resistance calculation under biaxial bending and economic design solutions.

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LIST OF SYMBOLS

A_a	Cross sectional area of steel profile
A_c	Cross sectional area of concrete
A_s	Cross sectional area of steel reinforcement
d	Diameter for circular sections / Edge length for square sections
e_{0y}	Applied load eccentricity along major section axis
e_{0z}	Applied load eccentricity along minor section axis
e_{top}	Applied load eccentricity at column top
e_{bot}	Applied load eccentricity at column bottom
E_a	Steel profile modulus of elasticity
E_s	Steel reinforcement modulus of elasticity
E_{cm}	Concrete secant modulus of elasticity
EI_{eff}	Flexural stiffness
$EI_{eff,II}$	Flexural stiffness to be used in moment amplification calculation
f_{cyl}	Cylinder concrete specimen resistance
f_{yd}	Design strength of steel profile
f_{yk}	Characteristic strength of steel profile
f_{ym}	Mean strength of steel profile
f_{sd}	Design strength of steel reinforcement
f_{sk}	Characteristic strength of steel reinforcement
f_{sm}	Mean strength of steel reinforcement
f_{cd}	Design strength of concrete
f_{ck}	Characteristic strength of concrete
f_{cm}	Mean strength of concrete
F_{ult}	Ultimate normal force
I_a	Second moment of area of steel profile
I_c	Second moment of area of concrete
I_s	Second moment of area of steel reinforcement
k	Moment amplification coefficient
M_α	Bending moment on interaction curve with an angle α from major axis at load level of interest
M_{Ed}	Design moment
$M_{pl,Rd}$	Fully plastic design moment resistance

$M_{ult,calc}$	Calculated internal second order moment corresponding to ultimate resistance
$M_{ult,FEA}$	Internal second order moment from FEA corresponding to ultimate resistance
$M_{y,Ed}$	Design moment about major axis
$M_{y,0}$	Bending moment on interaction curve about major axis at load level of interest
$M_{y,ult,test}$	Test ultimate section moment about major axis
$M_{z,Ed}$	Design moment about minor axis
$M_{z,0}$	Bending moment on interaction curve about minor axis at load level of interest
$M_{z,ult,test}$	Test ultimate section moment about minor axis
M_{I}	First order internal bending moment
M_{II}	Second order internal bending moment
N_{cr}	Elastic critical buckling load
N_{Ed}	Design Load
$N_{pl,Rd}$	Fully plastic design normal force resistance
$N_{G,Ed}$	Permanent design Load
$N_{pl,Rd}$	Plastic section design resistance
$N_{pl,Rk}$	Plastic section characteristic resistance
$N_{Test,100\%}$	Ultimate Test Resistance for Column Specimen
$N_{Test,80\%}$	80% of Ultimate Test Resistance for Column Specimen
$N_{Test,60\%}$	60% of Ultimate Test Resistance for Column Specimen
R_i	Vector from origin to interaction curve along R_p
R_p	Vector from origin to point of ultimate or design force and corresponding second order internal moment on strain limited interaction curve
$R_{p,i}$	Length of vector R_p divided by length of vector R_i
u	Midspan deflection
u_0	Magnitude of initial bow imperfection
u_{ult}	Midspan deflection at ultimate force
α	Biaxial bending moment's angle measured from major axis
α_M	Reduction factor from Eurocode 4 to account for section not reaching full plasticity
α_{MN}	Proposed reduction factor to account for section not reaching full plasticity
β	Coefficient based on moment distribution for calculating moment amplification
β	Proposed power value to determine biaxial interaction curves

β_{min}	Minimum power value obtained for a single section fitting a surface to the discrete 3D interaction surface points
ϕ	Reinforcement diameter
ε_{c1}	Concrete compressive strain at peak stress
ε_{cu1}	Concrete ultimate compressive strain
ε_y	Steel yield strain
ε	Strain
δ_0	Magnitude of initial bow imperfection
$\delta_{0,y}$	Magnitude of initial bow imperfection along major axis
$\delta_{0,z}$	Magnitude of initial bow imperfection along minor axis
σ	Stress
σ_c	Concrete Stress
$\overline{\lambda}$	Slenderness ratio
φ_t	Creep coefficient
θ	Angle on interaction curve measured from horizontal axis

LIST OF ACRONYMS/ABBREVIATIONS

3D	Three Dimensional
BC4	Building Code 4 (Singapore)
EC2	EN 1992-1-1
EC3	EN 1993-1-1
EC4	EN 1994-1-1
EN	European Norm
FEA	Finite Element Analysis
AISC	Length
CDP	Concrete Damaged Plasticity
HPC	High Performance Computing
NAD	Neutral Axis Depth

1. INTRODUCTION

1.1. Objective

Composite columns are widely in use for tall buildings. They have the advantage of utilizing both concrete and steel, to solve architectural challenges efficiently and utilize the column section area effectively. Most widely used composite column types are concrete filled steel tubes and concrete encased steel sections. For the former, existing literature is rich. For the concrete encased steel columns, the existing literature is limited, and slender column tests are very rare. Most of the existing tests are done on short columns with normal and high strength materials, but tall and slender column tests of this type are not common.

Presented dissertation focuses on the concrete encased steel columns' testing and finite element modelling with an aim to develop a design methodology taking into account biaxial bending. Eurocode 4 is the European Standard for composite structures and it is the regulatory document for design of these structures. Its simplified method's use is limited to concrete strengths up to C50/60 and structural steel grade up to S460. In addition, it adopts plastic section assumption as in steel structures. However, concrete encased steel sections have lower steel contribution ratio compared to other types and their failure is mostly governed by concrete. Strain limitation would be a safer and more accurate approach as opposed to plastic section assumption. All these issues are investigated in the presented work.

A recent testing campaign [1, 2] was taken as the main reference for testing of concrete encased steel columns for calibration of finite element model used in this dissertation. Full scale column tests are modelled in Section 3.1 and part of load introduction tests are modelled in 3.2. The column tests were successfully simulated by finite element analysis done in Abaqus with only initial bow imperfection being different for each sample. Magnitude of initial bow imperfection was used as a calibration parameter. Further investigation of test results revealed, especially for circular sections, use of an accurate biaxial bending - axial force interaction surface could result with economical advantages as opposed to existing methodology of Eurocode 4 for check of biaxial bending. It is presented in Section 4.3.

Load introduction tests from recent literature [2] were modelled to capture an accurate surface modelling methodology for steel and concrete in contact. The methodology and findings are summarized in Section 3.2.

After developing a successful FE modelling methodology for slender concrete encased steel composite columns, a parametric study was designed covering ranges of length, concrete strength, steel grade, reinforcing steel grade, load eccentricity, bending axis, existence of creep. In total, 2880 Abaqus runs were performed and for all of them, ultimate force and ultimate deflection values were extracted. The extracted data was used for developing an accurate second order flexural stiffness formulation to achieve good estimation of second order bending moments (p-delta effects). Details are in Chapter 6. A new design methodology is proposed for concrete encased steel sections which adopts strain-compatibility interaction curve for both cases of pure compression and compression in combination with uniaxial of biaxial bending.

1.2. Research Methodology

Since the aim of the work is to develop an accurate design method for concrete encased steel columns, first step is to understand the behaviour of such columns. Extensive literature review of testing of encased sections as well as background documents for their design standards revealed that the failure of this type of columns mainly depend on concrete and not structural steel. Concrete crushing was always the point at which ultimate resistance was reached. This distinct behaviour compared to other composite sections, make encased sections stand out. Usually, design standards for composite structures take steel design as basis, however encased sections behave similar to reinforced concrete sections although by norm they are classified as composite, depending on steel contribution ratio. The assumptions of fully plastic sections become error prone for concrete encased sections since straining capacity of concrete is limited. With light of this information, the approach hereby for design of these sections is adapts strain limitation.

To develop a working design method, an accurate FE model to use on tests from literature was necessary. This was done with historical tests. Initial bow imperfection to be used in design was set as an unknown in FE modelling and iteratively set to a final value averaging the best estimation of ultimate resistance. After accurately modelling tests, the developed FE model is used to model many cases including different material resistances and lengths to cover as large of a design base as possible. The parametric study results are firstly used to show the shortcomings of Eurocode 4's approach for designing centrically loaded columns (buckling curves). Then to conclude with a modified second order flexural stiffness to be used in second order internal moment calculation together with a modified initial bow imperfection on strain limited interaction diagram. Final proposal gives safe sided resistance compared to FE analysis for all parametric study cases. To enable further use of plastic interaction curves, a method to convert them to strain limited interaction curves is presented.

Finally, a novel method is presented for calculating biaxial bending resistance of encased sections without use of a dedicated software.

1.3. Scope

As the title suggests, the main typology considered in this research is concrete encased steel columns. Due to availability of literature tests, rectangular and circular sections are considered. Slenderness is an important characteristic of structural members under compression, to ensure it was reflected in the considered design cases, only the tests from the literature where buckling length to section dimension (or diameter) ratio greater than 10 were considered in developing the FE model. The main tests [1] modelled in this research had six meters length and a section length of 300 mm for square and a diameter of 350 mm for circular sections. Tests from literature as well as created sections for parametric study fit to the reinforcement and steel profile spacing requirements of Eurocode 4's simplified method. Circular encased sections are not covered by Eurocode 4's simplified method; for them, a realistic spacing for production process was considered mainly for the distance between flange tip and concrete surface.

The considered residual stress distribution for steel is only for hot rolled sections. Therefore, scope of the work excludes welded sections or possible other constellations.

Finite element model calibrated for this dissertation uses volume elements for concrete, line elements for reinforcement and shell elements for structural steel. Since shell finite elements are suitable only to model structural elements with high length to thickness ratio, sections with thick flanges and/or webs are out of the scope of the work. Nominal yield and ultimate strengths of structural steel classes considered herein are taken from Eurocode 3 for steels with nominal thickness less than or equal to 40 mm. Sections with steel having higher nominal thickness are out of the scope.

Finally proposed design method extends the material limitations of Eurocode 4 to C90 for concrete, S550 for steel and B700 for structural steel.

1.4. Literature Review

Existing literature on the design, testing and modelling of composite columns of steel and concrete were investigated. One significant finding was that most of the testing were conducted on stub columns. Therefore, the failure modes were due to material or section failure. For more accurate capturing of behavior of slender columns, more slender column loading tests are required. Using results from slender column tests, it would be possible to assess the flexural rigidity formulation to calculate buckling load in the composite guidelines. Current European composite standard Eurocode 4 [3] uses the same concept with steel standard [4] to calculate buckling capacity of composite columns. Imperfection factors and choice of buckling curve depends on the section geometry. Effect of concrete on buckling capacity has to be assessed. In addition, since high strength steel and concrete are not covered in current Eurocode 4, their incorporation requires assessment of buckling calculation methods for high strength materials as well.

Roik and Schwalbenhofer [5] tested 2 and 3 meters tall concrete encased steel columns as well as concrete filled steel tubes with normal strength steel and concrete. Testing campaign included loading with and without eccentricity by introducing it from the welding positions of end plates. This testing campaign had a total of 84 tests and is the most extensive test campaign found in the literature for composite columns. Although the slenderness of columns were not very high, results became significant resources for the development of German and European Composite design standards.

Lai et al. [6] tested three centric load rectangular concrete encased steel columns with a height of 2.8 m. They used high strength concrete with normal strength steel. They presented numerical analysis of the tests, derived an equation for effective flexural stiffness that was compared with approaches of Eurocode 4 [3], AISC [7], ACI [8] and Tikka [9,10]. Overall, they found all of the building codes to give conservative estimates for flexural stiffness.

Tikka [9, 10] presented a flexural stiffness formulation to be used for concrete encased steel slender columns' second order internal moment calculation. They derived the formulation using the linear elastic geometrically nonlinear beam deflection equation and executing several thousand of samples with that model. The presented flexural stiffness equation was formulated in terms of stiffnesses of each component of the section as well as load eccentricity and column slenderness.

Kim et al. [11] tested 4 square, 1 circular fully encased concrete encased steel columns and 2 partially encased square composite columns with high strength concrete and ultra high strength steel. The specimens were loaded eccentrically. Lengths of the specimens were 0.9 meters and total buckling length of the testing machine was 2.6 meters. Authors reported a brittle failure of concrete with an ultimate strain about 0.003. Authors went on to derive the effective flexural stiffness from test results using a back-calculation from analytical geometrically nonlinear beam deflection equation [12] and compared the obtained results with those from formulations of other building codes.

Kim et al. [13] tested 2 concrete filled steel tube columns and 4 concrete encased steel columns with high strength steel and concrete. Specimens were of 0.9 meters and 1.8 height. However, test machine was such that the effective length was varying between 2 and 3.5 meters. Authors derived interaction curves two show test failure load and moment on the interaction curve. They reproduced strain distribution of test specimens using strain compatible sectional analysis. They derived the flexural stiffness from test specimens using the approach of [9, 10, 12] and found Eurocode 4's approach to be nonconservative.

Nine slender concerete encased steel composite columns were tested and reported for which the author was part of the testing campaign by Bogdan et al. [1] funded by Arcelor Mittal. Five columns had circular cross sections and 4 columns had rectangular cross sections. High strength concrete was used together with high strength steel profile and normal reinforcement. Test results are reported in [1]. Test machine at Ruhr University of Bochum allowed for rotation of the column support in both major and minor axes. Also, exact eccentricities from the column centroid to the centroid of bearings at both column ends were measured using imaging technology. Exact eccentricities were never reported before in found literature for concrete encased steel column tests with hot rolled H-sections. This made the tests unique and since the author was part of the testing campaign, these tests published in [1] are used as a basis for the finite element analysis of this dissertation.

Table 1.1. Concrete Encased Steel Section Tests Found in Literature Fulfilling Slenderness Criteria Used to Calibrate FE Model

Reference	Year	Concrete	Steel Profile	Section	No of Tests
Roik [3]	1988	37 – 46.8 MPa	232 – 315 MPa	Rectangular	18
Liew [4]	2019	96 MPa	380 MPa	Rectangular	3
Kim [11]	2014	94 MPa	913 MPa	Rectangular & Circular	4
Kim [9]	2012	104 MPa	812 MPa	Rectangular & Circular	2
Bogdan [1]	2023	59.5 – 105.3 MPa	S500	Rectangular & Circular	9

Beer et al. [14] refers to measured steel column imperfections conducted on 500 steel beams. He concluded L/1000 was an acceptable initial bow imperfection value to be used in design of steel columns. It is a common approach found in literature that the composite columns are numerically modelled with an initial bow imperfection having a peak of L/1000 where L is the column length. This approach is adopted from steel structures but the focus of this dissertation is concrete encased steel columns. For the concrete encased steel columns, steel contribution can be low. In addition, due to the manufacturing processes, the column will take the shape of the concrete formwork.

Munoz [15] presented an analytical formulation for biaxially loaded rectangular concrete encased steel composite columns. They created a software that is able to create biaxial interaction surfaces and tested 80 columns to succesfully predict their failure loads.

Bergmann [16] explains the background on the effective flexural stiffness equation used in Eurocode 4 to calculate second order internal bending moment. He explains the reason behind different flexural stiffnesses given by the standard for slenderness calculation and internal moment calculation; the approach used to calculate equivalent imperfections. In other words, to be able to get a threshold value for imperfections, effective flexural stiffness had to be modified. This is referenced to the classification of composite columns to European buckling curves conducted by Bergmann [17] and Lindner [18].

Bergmann [17] presented the derivation of equivalent geometrical imperfections to be used for composite columns that are classified in Class a of European buckling curves. The procedure involves back-calculation of peak initial bow imperfection for a linear elastic beam column using second order analysis. Buckling curve reduction values are used as a starting point to move to plastic interaction curve and obtain the plastic moment capacity from which, beam equation is used to treat and obtain the initial bow imperfection to be used in simplified method of Eurocode 4 in combination with effective flexural stiffness. Lindner [18] did the same for the composite columns that are classified in classes b and c of European buckling curves. Both authors presented their findings as well as calculation examples [19].

Bergmann [20] developed a fiber section based beam finite element formulation to calculate load deformation behaviour of composite columns. Formulation allowed for introducing bow imperfections as well as residual stresses on steel by means of initial stress fields. Material and geometric nonlinearities were also incorporated in the formulation which made it suitable for use in modelling composite columns. Using his model, it was possible to classify the composite sections to European buckling curves after conduction numerous simulations with varying typologies of concrete filled tubes and concrete encased steel columns. In all the calculations, an initial bow imperfection with a peak of L/1000 was used where L is column length.

There are many more material and scientific research available in the relevant literature. However, to keep the dissertation focused on point, only the most relevant work from the literature is presented here.

2. STATE OF THE ART

Composite column design is regulated differently in different parts of the world. However, underlying causes of the behaviour of this type of columns are universal. In this chapter, the different standards for design of concrete encased steel composite columns are presented with their differences, they are compared tabularly. The considered standards are from Europe, USA, Australia and New Zealand and Singapore. European and Singaporean Standards are very similar to each other. Australia and New Zealand standard have some distinctions but focuses mostly on concrete filled steel tubes rather than encased sections. US standard is actually for steel design and has only a part about composite columns. Overall, Eurocode is the most extensive standard for composite design and therefore taken as a basis in this dissertation.

Following the discussion of different standards, the important phenomenon for concrete encased steel sections are discussed such as creep, concrete spalling, plastic vs strain compatibility approach for section resistance and interaction curves. Understanding them is crucial for developing a design method for concrete encased steel columns.

2.1. Design Standards for Encased Composite Columns

In this section, different composite design standards' approaches for design of composite columns are presented. The considered design standards are EN 1994-1-1: Eurocode 4 [3], AISC 360-16 [7], AS/NZS 2327 [21], BC4 (Singapore) [22].

2.1.1. EN 1994-1-1: Eurocode 4 [23]

Eurocode 4 is the European design standard designated for steel-concrete composite structural design. The standard is in harmony with EN 1992-1-1: Eurocode 2, the European design standard for reinforced concrete structures [24] and EN 1993-1-1: Eurocode 3, the European design standard for steel structures [4]. Two methods of design are given; general method and simplified method. Simplified method is applicable to members of doubly symmetrical and uniform cross sections over the elementh length shown in Figure 2.1. General method is applicable to members with non-symmetrical or non uniform cross-sections over the element length. General method allows for advanced numerical calculation taking account for second-order effects including residual stresses, geometrical imperfections, local instability, cracking, creep and shrinkage of concrete, yielding of structural steel and reinforcement. Simplified method of design is explained in the next sections. As of writing of this dissertation, actual draft of the new generation of Eurocode 4 was taken as basis for content [23]

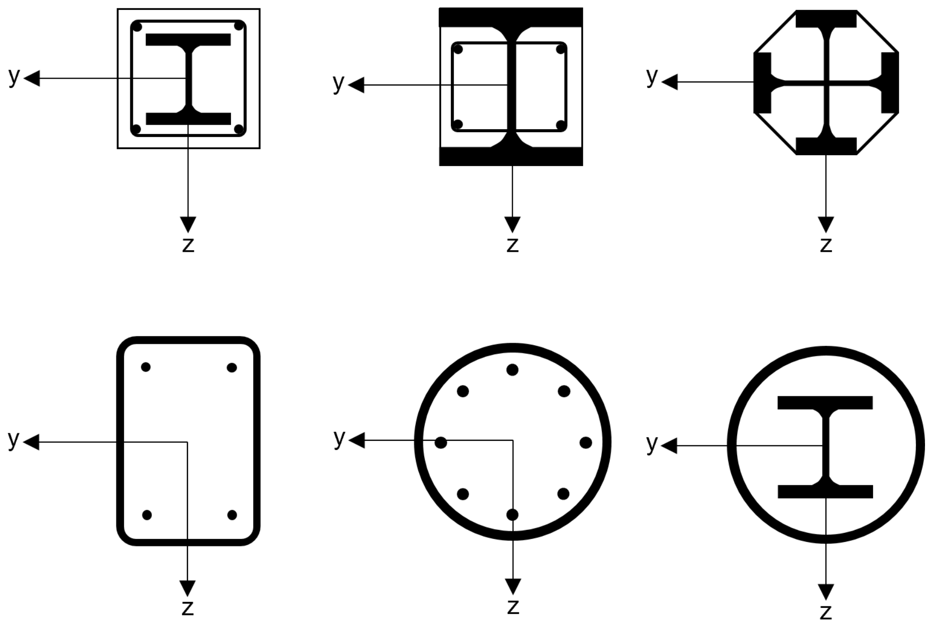


Figure 2.1. Sections for simplified method of Eurocode 4 [3]

2.1.1.1. Material strength limitations. Concrete strength class shall be between C20/25 and C50/60. Steel grade shall be between S235 and S460.

2.1.1.2. Members under axial compression. Design normal force N_{Ed} must satisfy Equation 2.1.

$$\frac{N_{Ed}}{\chi N_{pl,Rd}} \leq 1.0 \tag{2.1}$$

where;

$N_{pl,Rd} = A_a f_{yd} + 0.85 A_c f_{cd} + A_s f_{sd} \Rightarrow$ The plastic cross-section design resistance.

$A_a, A_c, A_s \Rightarrow$ Cross-section areas of steel profile, concrete and reinforcement, respectively.

$f_{yd}, f_{cd}, f_{sd} \Rightarrow$ Design strengths of structural steel, concrete and reinforcement steel, respectively.

$\chi \Rightarrow$ The reduction factor due to buckling and calculated from European buckling curve shown in Figure 2.2.

$$\chi = \frac{1}{\Phi + \sqrt{\Phi^2 - \overline{\lambda}^2}} \leq 1.0$$

$$\Phi = 0.5 \left[1 + \alpha \left(\overline{\lambda} - 0.2\right) + \overline{\lambda}^2\right]$$

$\alpha \Rightarrow$ Imperfection factor to be taken from Table 2.1

$\overline{\lambda} = \sqrt{\dfrac{N_{pl,Rk}}{N_{cr}}} \leq 2.0 \Rightarrow$ Relative slenderness.

$N_{pl,Rk} = A_a f_{yk} + 0.85 A_c f_{ck} + A_s f_{sk} \Rightarrow$ Plastic cross-section characteristic resistance.

$N_{cr} \Rightarrow$ Elastic critical buckling load calculated using EI_{eff}.

$EI_{eff} = E_a I_a + E_s I_s + 0.6 E_{c,eff} I_c$

$I_a, I_s, I_c \Rightarrow$ Second moments of area of steel profile, reinforcement and concrete, respectively.

$E_a, E_s \Rightarrow$ Moduli of elasticity of steel profile and reinforcement.

$$E_{c,eff} = E_{cm} \frac{1}{1 + (N_{G,Ed}/N_{Ed})\,\varphi_t} \tag{2.2}$$

$E_{cm} \Rightarrow$ Secant modulus of elasticity of concrete in acc. with Eurocode 2.

$N_{G,Ed}, N_{Ed} \Rightarrow$ Permanent and total design normal force.

$\varphi_t \Rightarrow$ Creep coefficient calculated in acc. with Eurocode 2.

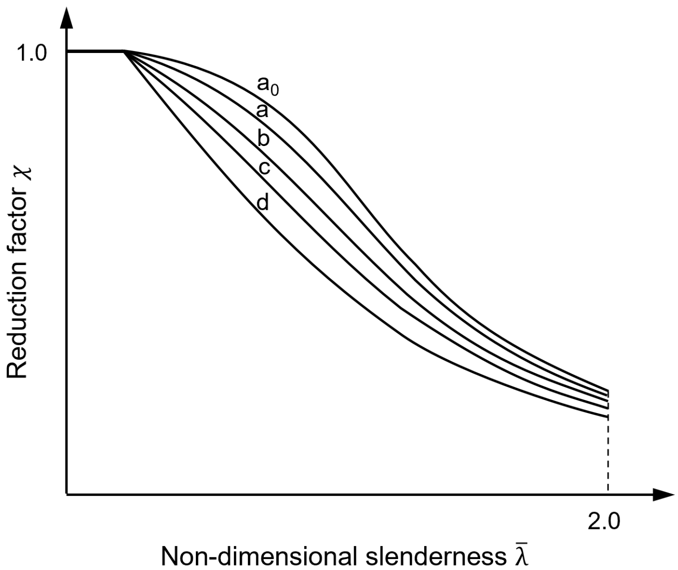


Figure 2.2. Buckling curves of Eurocode 3 [4]

Table 2.1. Imperfection Factors

Buckling curve	a_0	a	b	c	d
α	0.13	0.21	0.34	0.49	0.76

<u>2.1.1.3. Members under combined bending and compression.</u> The design control for composite columns under combined bending and compression shall be done using fully

plastic interaction curves. A simplified 4-point interaction can be used as shown in Figure 2.3.

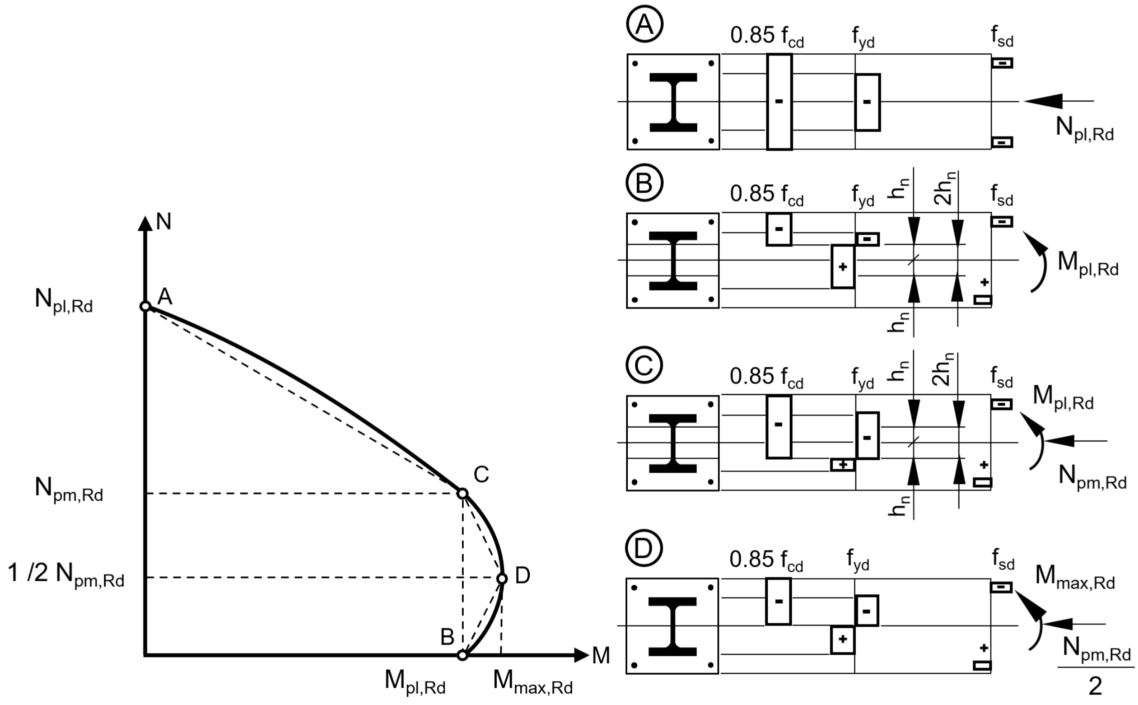


Figure 2.3. Plastic interaction curve for simplified method of Eurocode 4 [3]

Equation 2.3 has to be satisfied based on the interaction curve as shown in Figure 2.4.

$$\frac{M_{Ed}}{M_{pl,N,Rd}} = \frac{M_{Ed}}{\mu_d M_{pl,Rd}} \leq \alpha_M \tag{2.3}$$

where,

$M_{Ed} \Rightarrow$ Largest design moment along column length, taking into account imperfections and second order effects when necessary.

$M_{pl,N,Rd} = \mu_d M_{pl,Rd} \Rightarrow$ Plastic bending resistance corresponding to N_{Ed}

$$\alpha_M = \begin{cases} 0.9 & \text{for S235 and S355} \\ 0.8 & \text{for S420 and S460} \end{cases}$$

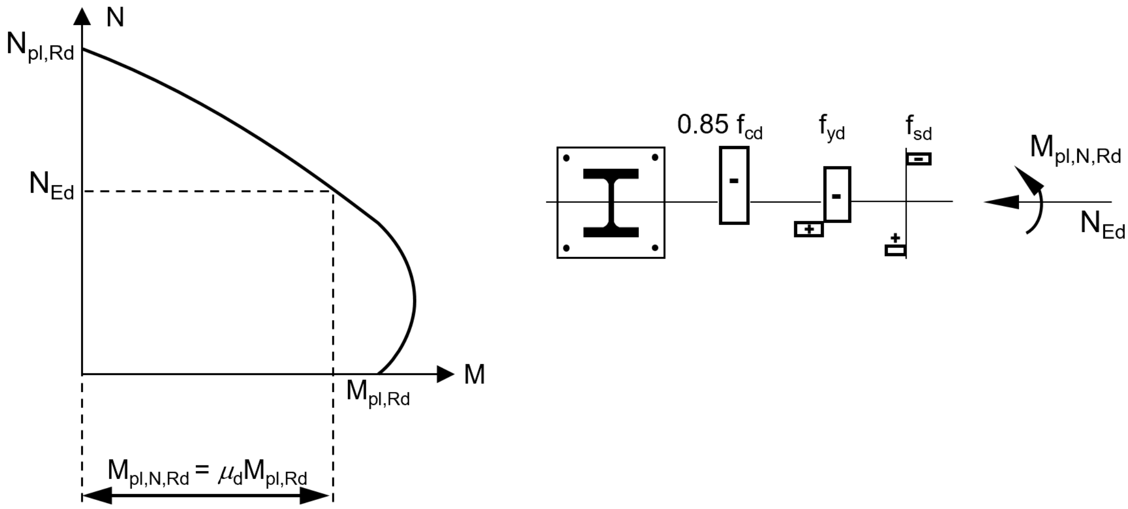


Figure 2.4. Interaction curve for section under compression and bending

2.1.2. AISC 360-16

AISC 360-16 is the specification for structural steel buildings published by American Institute of Steel Construction. Although the specification is for steel buildings, one chapter is designated for steel-concrete composite structures.

2.1.2.1. Material strength limitations.
Concrete compressive strength shall be between 21 MPa and 69 MPa.
Steel section yield strength shall not exceed 525 MPa.
Steel reinforcement yield strength shall not exceed 550 MPa.

2.1.2.2. Members under axial compression.
Nominal strength calculation of encased composite columns under axial compression depend on slenderness of the column which is quantified by P_{no}/P_e. Depending whether the slenderness of the column is greater or lower than 2.25, Nominal Strength P_n which is the strength before application of a safety factor is calculated as follows:

for $\dfrac{P_{no}}{P_e} \leq 2.25$

$$P_n = P_{no}\left(0.658^{\dfrac{P_{no}}{P_e}}\right) \tag{2.4}$$

for $\dfrac{P_{no}}{P_e} > 2.25$

$$P_n = 0.877P_e \tag{2.5}$$

where;

$P_{no} = F_y A_s + F_{ysr} A_{sr} + 0.85 f_c' A_c$

P_e = Elastic buckling load = $\dfrac{\pi^2 EI_{eff}}{L_c^2}$

F_y = Steel section yield stress (MPa)

A_s = Steel section cross-sectional area (mm^2)

F_{ysr} = Reinforcement yield stress (MPa)

A_{sr} = Reinforcement cross-sectional area (mm^2)

f_c' = Concrete compressive strength (MPa)

A_c = Concrete cross-sectional area (mm^2)

$EI_{eff} = E_s I_s + E_s I_{sr} + C_1 E_c Ic$ = Effective section stiffness (Nmm^2)

$$C_1 = 0.25 + 3\left(\frac{A_s + A_{sr}}{A_g}\right) \leq 0.7$$

E_s = Steel modulus of elasticity (200000 MPa)

I_s = Steel section moment of inertia (mm^4)

I_{sr} = Reinforcement moment of inertia (mm^4)

$E_c = 0.043 w_c^{1.5}\sqrt{f_c'}$ (MPa)

w_c = Concrete density ($1500 \leq w_c \leq 2500$ kg/m^3)

I_c = Concrete moment of inertia (mm^4)

L_c = Effective length of the column = KL

L = Unbraced column length

K = Effective length factor

2.1.2.3. Members under combined bending and compression. Bending resistance of concrete encased sections are permitted to be calculated with either,

-Elastic stress distribution considering first yield in the tension flange of the profile

-Plastic flexural strength of the steel section alone

-Section resistance based on plastic stress distribution or strain-compatibility (strain limited design)

AISC 360-16 allows use of 3 different approaches for the interaction between bending and compression for encased columns.

1) Bilinear interaction diagram that is taken from steel design and is more con-

servative with increasing concrete contribution in the section

2) Four point interaction diagram for the section assuming plastic behaviour of the section. Reduction due to the slenderness of the section is accounted for in the diagram.

3) Using the AISC Design Guide 6 [25]

2.1.3. AS/NZS 2327

AS/NZS 2327 [21] is the standard for composite structures - composite steel-concrete construction in buildings for Australia and New Zealand.

2.1.3.1. Material strength limitations.
Concrete compressive strength shallnot exceed 100 MPa
Steel section yield strength shall not exceed 690 MPa.

2.1.3.2. Members under axial compression.
AS/NZS 2327 requires a minimum bending moment considered in design equal to design axial force times 0.05D where D is the column depth for the bending direction.

The plastic cross-section resistance for encased composite columns is calculated by Equation 2.6

$$N_{us} = 0.9A_{se}f_y + (0.6)0.85A_cf_c + 0.9A_sf_{sy} \tag{2.6}$$

where;

$A_{se}, A_c, A_s \Rightarrow$ Cross sectional areas of steel profile, concrete and reinforcement, respectively.

$f_y, f_{sy} \Rightarrow$ Yield strength of steel profile and reinforcement, respectively.

$f_c \Rightarrow$ Characteristic compressive strength of concrete.

Nominal member capacity of composite column with constant cross-section is determined by Equation 2.7.

$$N_{uc} = \alpha_c N_{us} \leq N_{us} \tag{2.7}$$

where;

$\alpha_c = \xi \left[1 - \sqrt{1 - \left(\frac{90}{\xi \lambda} \right)^2} \right] \Rightarrow$ Slenderness reduction factor.

$$\xi = \frac{\left(\frac{\lambda}{90} \right)^2 + 1 + \eta}{2 \left(\frac{\lambda}{90} \right)^2}$$

$$\lambda = \lambda_\eta + \alpha_a \alpha_b$$

$$\eta = 0.00326 \left(\lambda - 13.5 \right) \geq 0$$

$$\lambda_\eta = 90 \lambda_r$$

$$\alpha_a = \frac{2100 \left(\lambda_\eta - 13.5 \right)}{\lambda_\eta^2 - 15.3 \lambda_\eta + 2050}$$

$\alpha_b = 0$ for bending about strong axis and 0.5 for bending about weak axis of encased sections

$\lambda_r = \sqrt{\frac{N_s}{N_{cr}}} \Rightarrow$ Relative slenderness.

$$N_s = A_{se} f_y + 0.85 A_c f_c + A_s f_{sy}$$

$$N_{cr} = \frac{\pi^2 EI_e}{L_e^2}$$

$L_e \Rightarrow$ Effective length. Calculated by effective length factor from AS 4100 [26] or NZS 3404 [27].

$$EI_e = E_s I_s + E_r I_r + E_{c,eff} Ic$$

$I_s, I_r, I_c \Rightarrow$ Second moments of area for structural steel , reinforcement and uncracked concrete section, respectively.

$E_s, E_r \Rightarrow$ Moduli of elasticity for structural steel and reinforcement, respectively.

$$E_{c,eff} = E_c \frac{1}{1 + \left[\frac{N_G}{N_G + N_Q}\right] \phi_{cc}}$$

$$E_c = \begin{cases} \rho_c^{1.5} 0.043 \sqrt{f_{cmi}} & \text{for } f_{cmi} \leq 40MPa \\ \rho_c^{1.5} \left(0.024\sqrt{f_{cmi}} + 0.12\right) & \text{for } f_{cmi} > 40MPa \end{cases}$$

$\rho_c \Rightarrow$ Density of concrete in kg/m^3.

$f_{cmi} = 0.9\,(1.2875 - 0.001875 f_c)\, f_c \Rightarrow$ Mean compressive strength of concrete.

$N_G \Rightarrow$ Unfactored axial permanent compressive load.

$N_Q \Rightarrow$ Unfactored axial imposed compressive load.

$\phi_{cc} \Rightarrow$ Creep coefficient. Closed form time dependent creep coefficient calculations as well as tabular data for creep coefficient at 30 years after concrete casting are available in AS/NZS 2327.

Alternatively to the abovementioned formulations, tabular data is available in AS/NZS 2327 to directly obtain α_c values based on modified member slenderness $\lambda\eta$ and member section constant α_b.

2.1.3.3. Members under combined bending and compression. The standard does not provide a method for concrete encased steel sections under combined bending and compression. It covers only filled tubes for combined actions and uses a plastic interaction curve.

2.1.4. BC4 (Singapore)

In Singapore, Eurocode 4 is adopted and extended to cover composite columns having high strength materials, namely concrete up to C90 and structural steel up to S550. BC4:2021 [22] is the official document giving specifications for design of composite columns with high strength materials. It covers both concrete encased steel columns and concrete filled steel tubes. Liew [28] explained in his book, the approach and scientific background for the development of BC4:2021.

In this section, the methodology for including high strength materials as an extension to Eurocode 4 used by BC4 will be summarized as presented in [28].

2.1.4.1. High Strength Material Properties. Extension of concrete strength coverage was done with a modification to the concrete strength from C50 to C90. A reduction factor η was introduced as given in Equation 2.8. Characteristic cylinder strength shall be multiplied by η. Reasoning for introduction of a reduction factor was calibration of extensive amount of tests for concrete filled steel tube from the literature. It is also used for calculating reduced modulus of elasticity for high strength concrete as in Equation 2.9.

$$\eta = 1.0 - \left(f_{ck} - 50\right)/200 \quad 50N/mm^2 < f_{ck} \leq 90N/mm^2 \tag{2.8}$$

$$E'_{cm} = 22[\left(\eta . f_{ck} + 8\right)/10]^{0.3} \tag{2.9}$$

Structural steel up to S550 and reinforcing steel up to yield stress of 600 N/mm^2 are permitted.

2.1.4.2. Material Compatibility. Although high strength steel and concrete are allowed, not every combination is acceptable to ensure the yielding of steel. The compatibility of concrete and steel are shown in Table 2.2

Table 2.2. Material Compatibility for Composite Design [22]

	S235 to S355	S420	S460	S500	S550
C12/15 to C20/25	✓	×	×	×	×
C25/30 to C30/37	✓	✓	×	×	×
C35/45 to C40/50	✓	✓	✓	×	×
C45/55 to C60/75	✓	✓	✓	✓	×
C70/85 to C90/105	✓	✓	✓	✓	✓

2.1.4.3. Cross Section and Member Resistance. For combined normal force and bending, interaction curves considering rectangular stress blocks are to be used just as in Eurocode 4. α_M for steel grades greater than S420 is set to be 0.8.

2.1.5. Conclusion

In this section, several building codes from around the world are presented by their methodologies of calculating resistances of concrete encased steel sections.

European reinforced concrete design standard Eurocode 2 allows for use of concrete up to C90/105 and reinforcement B700, however Eurocode 4 limits them to C50/60 and S460, respectively.

Singapore composite building code is an extension to Eurocode 4 and it increases the material resistance upper limits in the scope. Its one major modification to Eurocode is the reduction factor applied to concrete stiffness equation for concrete classes above C50/60. AS/NZS 2327 is limited in its coverage of concrete encased steel sections and focuses mode on filled tubes. AISC 360 is a steel specification and only has a chapter for composite structures without much detail. The main points of the previously mentioned codes are presented in Table 2.3. Focus on the table was put in values used to calculate second order effects since this is the main phenomenon researched in this dissertation.

Table 2.3. Comparison of Different Building Codes for Values Used to Calculate Second Order Moments for Concrete Encased Composite Columns.

Clauses	Eurocode 4	BC4 (Singapore)	AISC 360
$EI_{eff,II}$	$0.9(E_aI_s+E_sI_s+0.5E_{c,eff}I_c)$	Same as Eurocode	$E_aI_s+E_sI_s+C_1E_cI_c$ $C_1=0.25+3(A_s+A_l)/A_g \leq 0.7$
$E_{c,eff}$	$E_{cm}[1+(N_{G,Ed}/N_{Ed})\ \varphi_t]^{-1}$	Same as Eurocode	-
E_{cm} (E_c for AISC)	$9500f_{cm}^{1/3}$	$22[(\eta f_{ck}+8)/10]^{0.3}$ $\eta = 1-(f_{ck}-50)/200$ for $50< f_{ck}(MPa) \leq 90$ $\eta = 0.8$ for $f_{ck}(MPa) > 90$	$0.043w_c^{1.5}\sqrt{f'_c}$
Initial Bow Imperfection	L/150, L/200	Same as Eurocode	Not Specified
Upper Limit of Material Resistances	C50/60 S460	C90/105 S550	Concrete: 69 MPa Profile Steel: 525 MPa

2.2. Important Phenomena for Encased Column Behaviour

There are several important phenomenon that must considered in design of encased columns such as creep and spalling. Creep is the long term effect of sustained loading on concrete. Testing encased columns for creep is not feasible due to time constraints and costs associated with large scale tests. Roik et al published creep test results [29–31] which are few examples of tests in this field. With lack of recent test data, its coverage in scientific publications is not common. Spalling is the loss of concrete cover which is an already known phenomenon from reinforced concrete.

2.2.1. Creep

Creep is the change of concrete's stress-strain behaviour under long term loading. It is time dependent, meaning the initial time at which the loading is applied, its magnitude, the time of measurement of creep are all inputs for the magnitude of creep. Creep's effect on concrete is essentially causing larger strains under same stress level compared to short term loading conditions. In addition to the loading, the structural member's dimensions, cement class and humidity of the environment are other factors on which long term effects depend. Creep affects resistance of structural members with concrete. These can be prestressed reinforced concrete or composite. Concrete encased steel columns are also susceptible to creep since they have concrete exterior. Due to creep, modulus of elasticity of concrete will reduce and the deflection of the concrete encased steel column will be expected to be more important than the case without creep. This will result with larger deformation and therefore larger internal moments. For stability analysis, this is of significant importance. On the other hand, increased straining capacity of concrete with creep will allow for more utilization of structural steel and reinforcement. This can be beneficial for the capacity of the cross-section.

Annex B of EN 1992-1-1 gives an advanced calculation method for creep coefficient at an arbitrary age of concrete. EN 1994-1-1 refers to monograms from EN 1992-1-1 for calculation of creep coefficient at 70 years of age of concrete. The monograms are simpler to use, but they result with high values of creep coefficient when the analysis is to be done at an age of structure earlier than 70 years. Application of creep coefficient on composite columns takes places when calculating the modulus of elasticity. E_{cm} is reduced by the creep coefficient to obtain $E_{c,eff}$. This reduction is given in Equation 2.2 and depends also on the ratio of permanent design normal force to the total design normal force. Obtained $E_{c,eff}$ is used to calculate slenderness ratio of the composite column that is then input to the buckling curve to obtain the resistance of centrically loaded composite columns covered by simplified method of EN 1994-1-1. $E_{c,eff}$ is also used to calculate the second order effects (p-delta) and moment amplification coefficient when using the simplified method. A reduced modulus of elasticity ensures a safe sided solution by estimating large moment amplification values.

EN 1994-1-1 general method for calculating column resistance requires the designer to consider creep but does not clearly state how to do it. The method requires an advanced nonlinear finite element analysis solution. Therefore, the question of how to consider creep for concrete encased steel column finite element analysis becomes crucial. Sources [29–35] discuss this issue but there has yet to be found a consensus on how to tackle it. Since most of the tests in the literature for composite columns are performed under short term loading, experimental data is also not available on large scale for possible calibration. Advanced general purpose finite element analysis software have load rate dependent material property modelling approaches available but applicability to structural engineering and composite columns is not proven. In this dissertation, the approach to modify the stress-strain curve of concrete is used [33, 36]. The long term creep coefficient is multiplied by ratio of permanent load to total design load that was assumed as 0.7 same as [33]. This value is an "effective" creep coefficient and is used to modify stress-strain curve as in Figure 6.2. This approach is used in Chapter 6 in parametric study.

2.2.2. Spalling

Extensive literature exists about the spalling of concrete cover on reinforced concrete sections prior to reaching strength of the concrete [37–42]. Higher strength concrete is much more susceptible to cover spalling than normal strength concrete. Spalling occurs due to the characteristics of contact region between core and cover concrete. Core concrete is highly confined due to transverse reinforcement which increases its ductility as well as stressing capacity along the column axis. Cover concrete on the other hand does not have the beneficial effects of ductility. Increased straining capacity of core concrete is in spacial continuity with the cover concrete on the interface, the distribution of stresses in horizontal direction on the interface causes breaking of the contact between cover and core concrete which distributes along the member to create the phenomenon of spalling. Tests from the literature [11, 13, 42] show that spalling of cover is followed by buckling of longidutinal reinforcement at the region of spalling. This is observed much more common for high strength concrete. Limited ductility and flexibility of high strength concrete compared to normal strength concrete can explain this behaviour.

Spalling of cover concrete is a significant threat for concrete encased steel sections since this typology attains its resistance mostly from concrete. As soon as cover spalls, it is certain that maximum capacity of the column is reached. Amount and type of longitudinal as well as transverse reinforcement, depth of cover concrete and loading conditions are all factors that affect if the spalling will occur. EN 1994-1-1 does not cover high strength concrete and therefore has no consideration of spalling danger. Although EN 1992-1-1 does cover concrete class up to C90, there is no reduction of design strength for concrete specifically for high strength classes. FprEN 1992-1-1 [43] introduces new parameters when calculating the design strength from the characteristic strength of concrete. These parameters are η_{cc} and k_{tc}. η_{cc} was introduced to consider the effect of sustained loads on the concrete resistance and k_{tc} to cover the difference between the strength of undisturbed cylinder concrete specimen and strength that can be developed on the structural member. Description of k_{tc} fits for the effect of spalling and can be said to cover it. Adopting an additional reduction factor as proposed by [42] would further reduce the design resistance of concrete to very low values.

2.3. Cross Section Resistance

To obtain cross section resistance of composite columns interaction curves are used. Interaction curves are plots of bending moment vs axial force resistance of sections. On the interaction curve, each point corresponds to an axial force and a bending moment combination on that section leading to failure. EN 1994-1-1 simplifies creating the interaction curves assuming fully plastification of section. Concrete tension is ignored and rectangular stress blocks are assumed for stress distribution on the section. Four point interaction curve as in Figure 2.5 is allowed for as a simplification instead of creating continuous interaction curves.

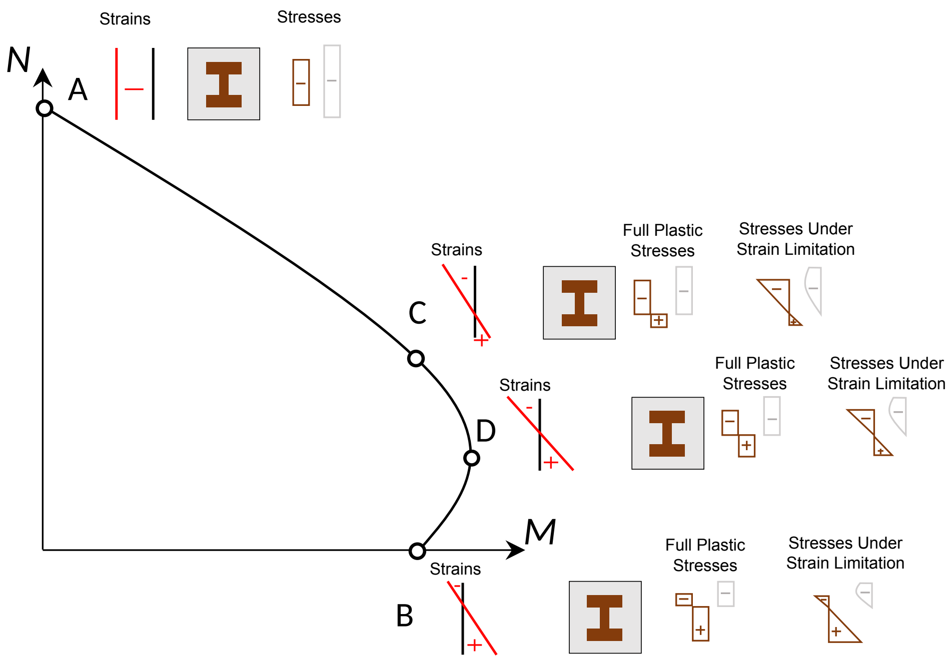


Figure 2.5. Interaction Curve and Possible Stress Distributions

At point A, the section is in full compression. Short, bulky columns would fail in this aroung this region. The other extreme, point B is full bending. This is ideal behaviour of a beam instead of a column. The members said to be governed by tensile failure and compressive failure when they are nearer to points B or A, respectively. Point D is also called the balance point. At balance point, the neutral axis passes through the midline of the section. This is the point where a column has its maximum bending resistance. For plastic interaction curves, normal force resistance at point point C is always twice of that at point D. This ensures the part of the curve below C to be symmetric about a horizontal line passing through D.

Rectangular stress blocks are a simplification for the stress distribution on the section. Beam theory assumes plane sections to remain plane and therefore a linear strain distribution over the section. With bending, when outer concrete fiber reaches crushing strain under compression, inner fibers will not be at the crushing strain. They will undergo lower strains and therefore rectangular stress blocks will not form. Especially for the typology that is investigated in this dissertation, namely concrete encased steel sections. For these sections, when outer concrete fiber crushed, section already reached its resistance. Eurocode 4 applies a reduction factor α_M to moment resistance to account for this phenomenon. α_M is investigated deeper in Section x. Principally, this dissertation relies on strain limited interaction curves rather than fully plastic for the reason explained above.

Nonlinear stress-strain relationship for concrete, structural and reinforcing steel from Eurocode 2 and 3 are adopted in this dissertation for creation of interaction curves and FE analysis models. Mean material resistances are used unless otherwise specified for two reasons: first, Eurocode 2 specifies concrete modulus of elasticity based on mean resistances and second, to prevent possible loss of stiffness when only reducing strengths. Design resistances are used for the parts where general method was used. For those, initial stiffness and material resistance was reduced as shown in Figure 2.6. The initial stiffness did not play a significant role in those instances because the failure of section does not happen before concrete in critical region reaches ultimate strains. According to Eurocode 2, two different stress-strain relationships for concrete can be used. These are parabola-rectangle and nonlinear. Parabola-rectangle ignores the descending branch unlike the nonlinear. Moreover, nonlinear stress-strain relationship is defined for mean concrete resistance consistent with the approach for this dissertation. Therefore, nonlinear stress-strain curve from FprEN1992-1-1 [**?**] (new generation Eurocode 2) is used for concrete. Reinforcing steel was modelled by a bilinear stress-strain curve and structural steel was modelled by multilinear stress-strain curve in accordance with EN 1993-1-14. Steel stress-strain relationship is available for characteristic strains, switch to mean resistances was done by increasing the characteristic resistance to means in acc. with Eurocode 4 but keeping the initial stiffness constant. Used mean and design stress-strain curves are shown in Figures below for concrete, structural steel and reinforcement.

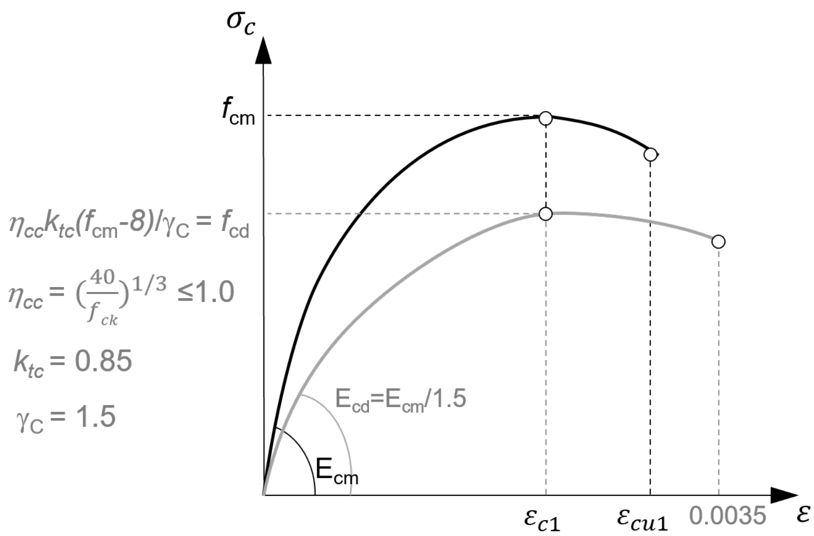


Figure 2.6. Mean and Design Stress-Strain Curves for Concrete in accordance with FprEN1992-1-1

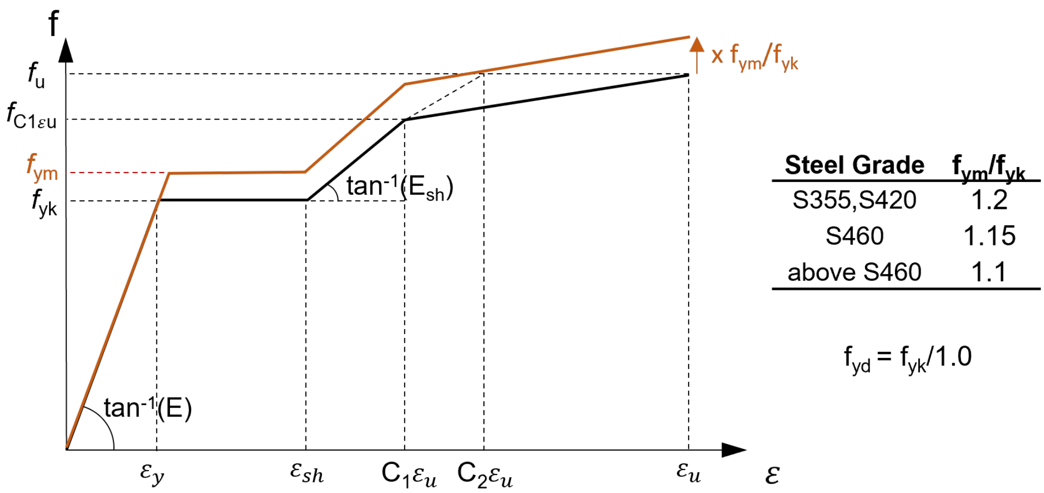


Figure 2.7. Mean and Design Stress-Strain Curves for Structural Steel

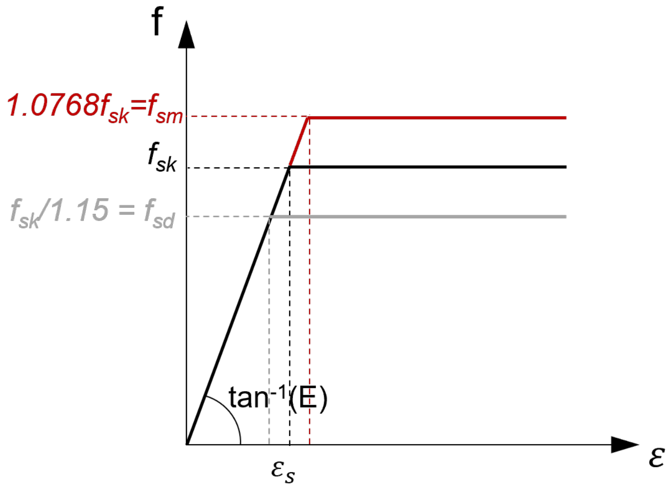


Figure 2.8. Mean and Design Stress-Strain Curves for Reinforcement

3. NUMERICAL MODELLING

The tests detailed [1,2] were numerically modelled using Finite Element Analysis software Abaqus [44]. This chapter contains the model properties and comparison of test results with numerical simulations.

3.1. Modelling of Column Tests

The testing campaign reported in [1] contains nine concrete encased steel column tests with test data given in Table 3.1. The exact loading eccentricities as well as material properties are known. Since these are the most recent tests for this typology and author was part of the testing campaign, they are taken as a basis for the finite element model development in this chapter.

Table 3.1. Column Specimen Details [1]

Specimen	Section Type	$f_{cyl,test}$ (MPa)	$E_{cm,test}$ (MPa)	Long. Rebar	Stirrups	Length (m)	Buckling Length (m)
A1.1	Circular	90.9	36229	8ϕ16	ϕ10/75 mm	6	6.3
A1.2	Circular	86.3	37008	8ϕ16	ϕ10/75 mm	6	6.3
A1.3	Circular	88	35115	8ϕ16	ϕ10/75 mm	6	6.3
A1.4	Circular	59.5	33477	8ϕ16	ϕ10/75 mm	6	6.3
A1.5	Circular	98.9	36296	12ϕ20	ϕ10/75 mm	6	6.3
B1.1	Square	91.4	36986	8ϕ16	ϕ10/75 mm	6	6.3
B1.2	Square	89.1	34550	8ϕ16	ϕ10/75 mm	6	6.3
B1.3	Square	105	38171	8ϕ16	ϕ10/75 mm	6	6.3
B1.4	Square	92.7	35161	12ϕ20	ϕ10/75 mm	6	6.3

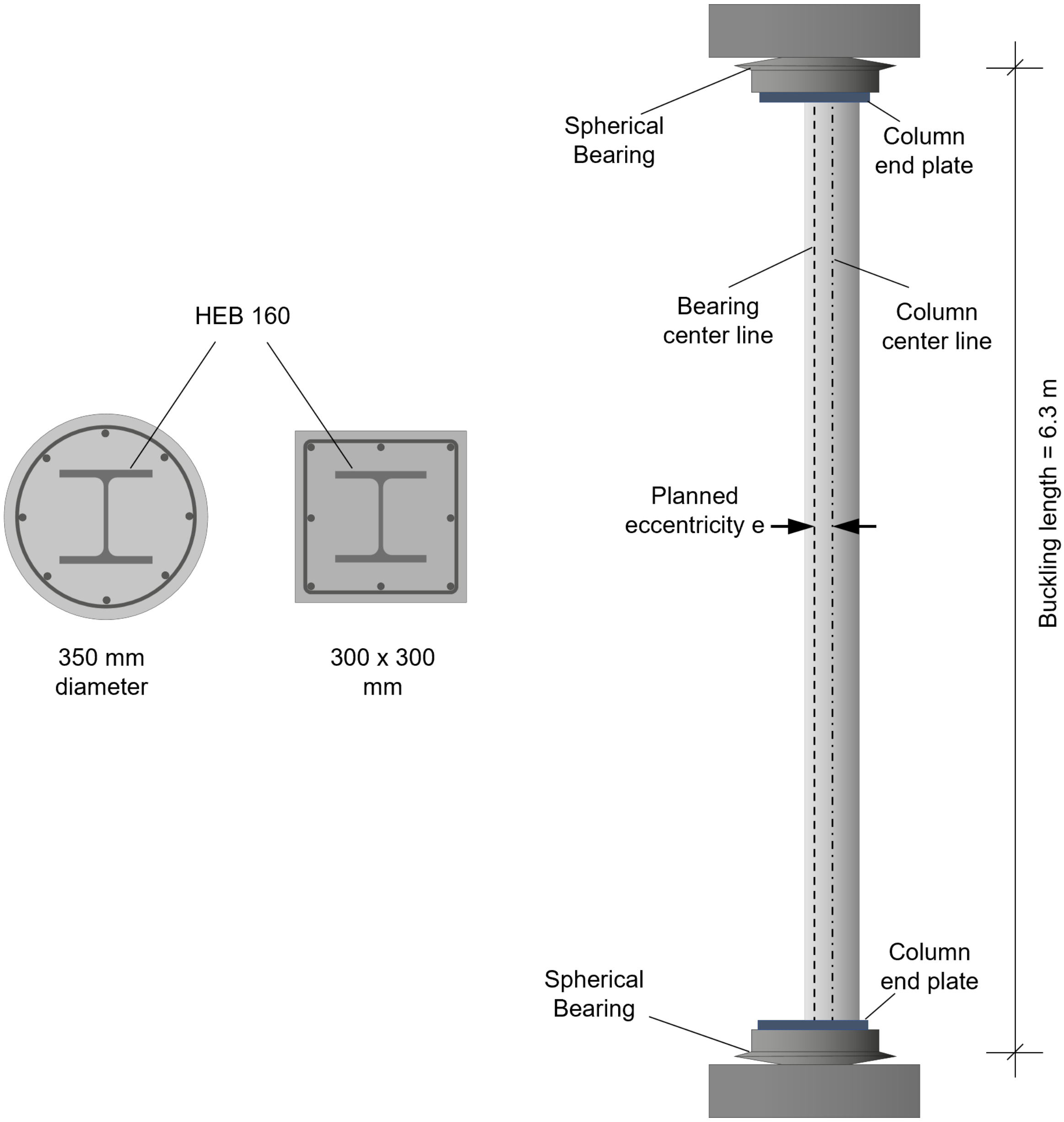


Figure 3.1. Column tests setup [1]

The test campaign for encased columns consisted of 9 columns, 5 of which had circular concrete encased steel sections and 4 had square encased sections. Steel sections were of shape HEB 160. As shown in the test setup in Figure 3.1, rotatable spherical bearings of the testing machine ensured buckling length to be known. By connecting the steel profile of the column to the end plates in an eccentric manner, the load eccentricity was provided. A1.1 was planned to buckle about weak axis and all the other specimens were planned to buckle about strong axis.

Each simulation had two steps. First, linear buckling analysis and second, the explicit dynamic analysis which used the single-curvature buckling shapes for strong and weak axes from the buckling step as initial displacement fields. Because explicit dynamic analysis can take into account nonlinearities from geometry and material, it was chosen over standard static analysis. It was discovered that static analysis had convergence issues, particularly for the material model utilized, Concrete Damaged Plasticity (CDP). A mass scale value of 100 and a smooth step loading with an average loading rate of 1 mm/s revealed low enough kinetic energy in the entire model, according to earlier research [45].

3.1.1. Material Properties

3.1.1.1. Concrete. Initial modulus of elasticity and cylinder compressive strength of concrete were measured at the test site and given in Table 3.1. In the abscence of an empirical stress-strain relationship, Eurocode 2's nonlinear stress-strain definition for concrete was adopted with modification. The ε_{c1} value was taken as 0.0035, higher than what the Eurocode 2 gives, and the descending branch was taken as linearly going down until a strain value of 0.01 and 10% of the ultimate stress as shown in Figure 3.2. Without the modification, simulations resulted with an abrupt decrease in load deflection curve which was not the case for most of the specimens. With the adopted modified stress-strain relationship, not only the descending but also ascending branch of the simulation load-deflection curves gave good match with test results. Concrete damaged plasticity was chosen as the material model in Abaqus with mesh properties of C3D8R with plasticity parameters shown in Table 3.2.

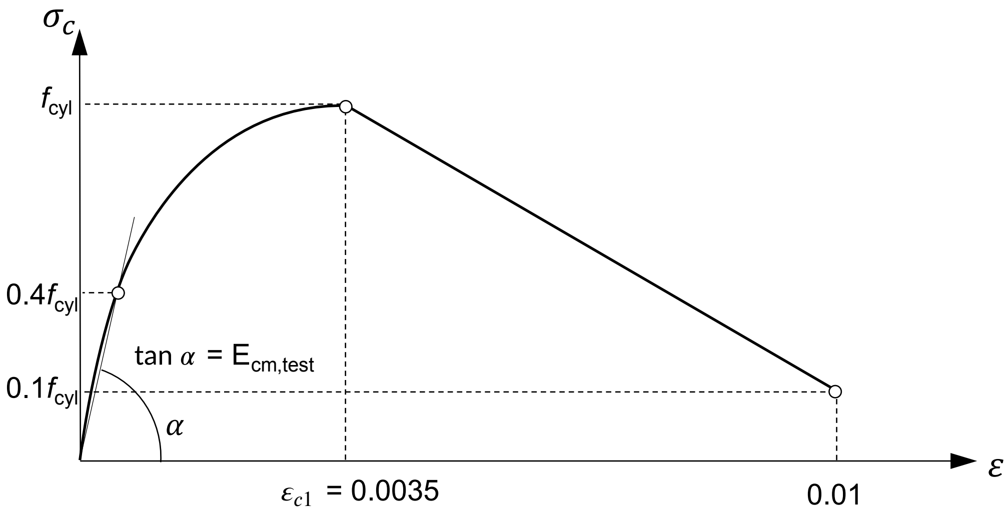


Figure 3.2. Concrete Uniaxial Compressive Stress-Strain Relationship Used in FEA

Table 3.2. Plasticity Parameters for Column Models

Dilation Angle	Eccentricity	f_{b0}/f_{c0}	K	Viscosity Parameter
35	0.1	1.16	0.67	0.0001

<u>3.1.1.2. Structural Steel.</u> Young's modulus of 210 GPa was used for HEB160 profiles. Multilinear stress strain relationship was adopted from EN 1993-1-14 [46]. The stress-strain behaviour is given in Figure 3.3. S4R Shell elements with 5 integration points were used to model the structural steel.

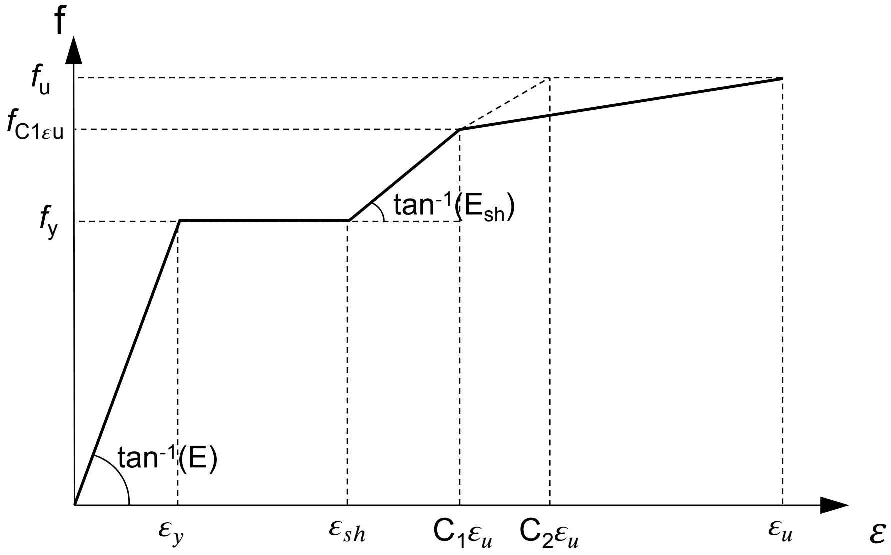


Figure 3.3. Steel Stress-Strain Relationship Used in FEA [46]

In Figure 3.3;

$f_y \Rightarrow=$ Yield stress

$E \Rightarrow$ Elasticity modulus

$\varepsilon_y = f_y/E \Rightarrow$ Yield strain

$f_u \Rightarrow$ Ultimate stress

$\varepsilon_{sh} = 0.015 \leq \dfrac{0.1 f_y}{f_u} - 0.055 \leq 0.03 \Rightarrow$ Strain hardening strain

$\varepsilon_u = 0.06 \leq 0.6\left(1 - \dfrac{f_y}{f_u}\right) \leq A \Rightarrow$ Ultimate strain

$A \Rightarrow$ Elongation after fracture per relevant material

$$C_1 = \frac{\varepsilon_{sh} + 0.25\left(\varepsilon_u - \varepsilon_{sh}\right)}{\varepsilon_u}$$

$$E_{sh} = \frac{f_u - f_y}{C_2\varepsilon_u - \varepsilon_{sh}} \Rightarrow \text{Strain hardening modulus}$$

$$C_2 = \frac{\varepsilon_{sh} + 0.4\left(\varepsilon_u - \varepsilon_{sh}\right)}{\varepsilon_u}$$

3.1.1.3. Reinforcement. Longitudinal and transverse reinforcement were modelled with elastic-perfectly plastic stress strain relationship as allowed for in Eurocode 2 with a young's modulus of 200 GPa. B31 beam finite elements were used.

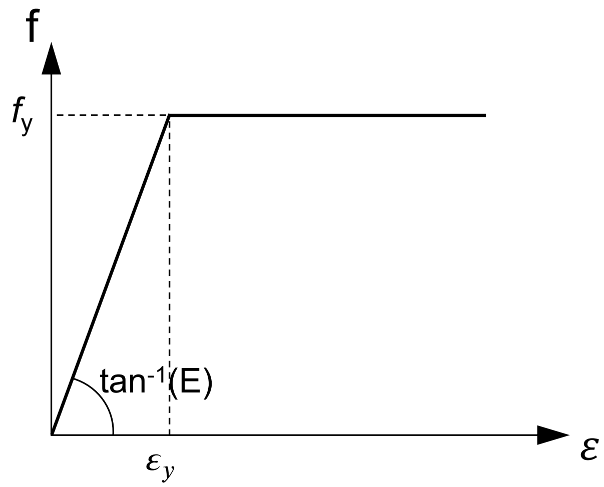


Figure 3.4. Reinforcement Stress-Strain Relationship Used in FEA [24]

3.1.2. Interactions/Constraints

In the test setup, column end plates were welded to the structural steel and the end plate was bolted to the test machine restraining any relative displacement. To imitate this behaviour in Abaqus, reference points were created at the center of rotation of bearings. Exact locations of the bearing centroid relative to column's centroidal axis was measured in testing since this relative displacement has significant impact on the scale of internal moments. The approach is illustrated in Figure 3.5.

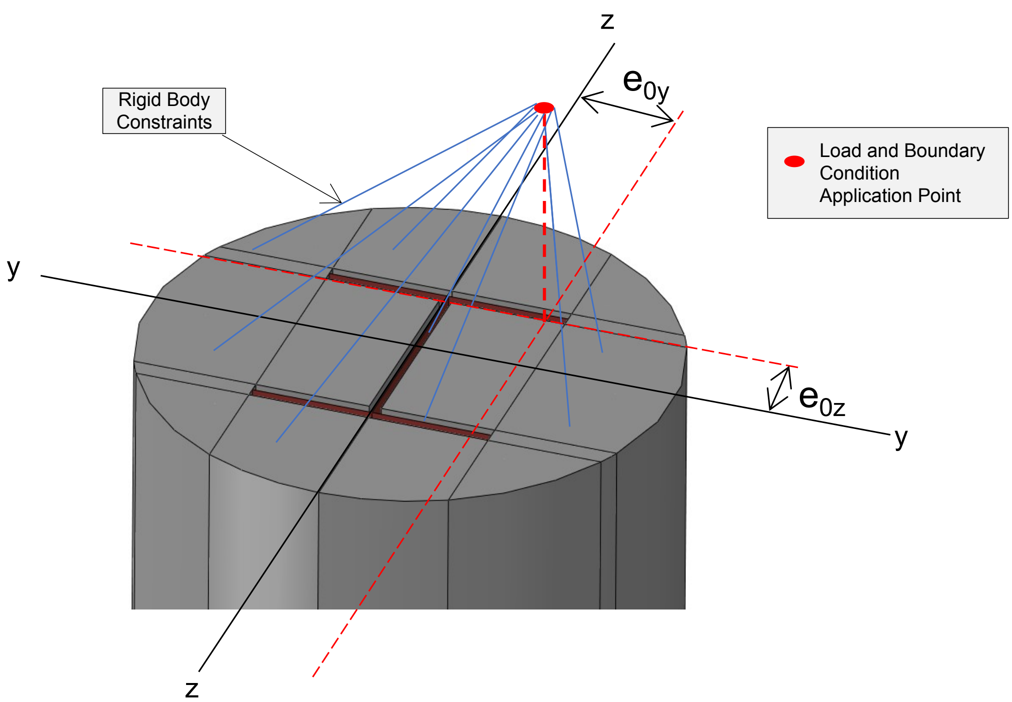


Figure 3.5. Abaqus Boundary Condition and Constraints with Eccentricity

The friction coefficient between steel and concrete was taken as 0.5 as per Eurocode 4 but this did not have any impact on the column behaviour since the relative displacements of the steel profile and concrete was restrained at the column ends with end plates.

3.1.3. Discretization

The mesh dimensions can be seen in Figure 3.6. Iterative convergence studies were done to come to an efficient mesh size [45]. The specimens were modelled on full scale without using symmetrical boundary conditions since both ends of the columns had different eccentricities.

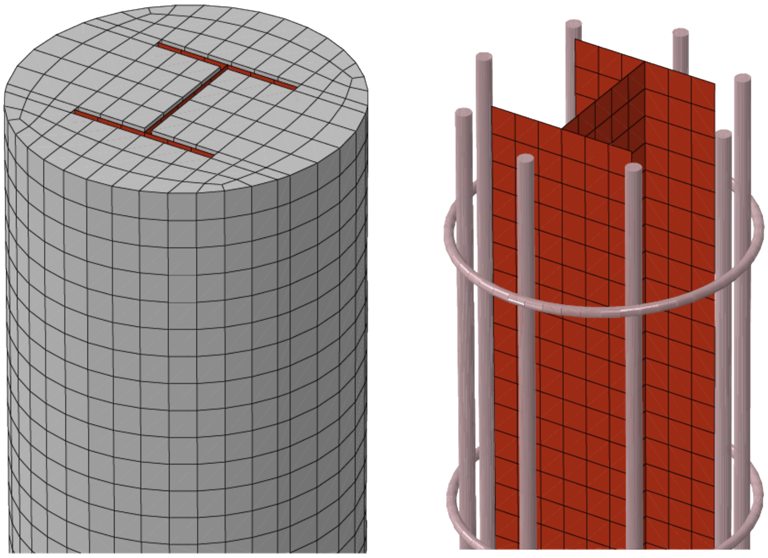


Figure 3.6. Mesh of Column Models

3.1.4. Imperfections

Some sources of imperfection can be listed as non-straightness, unplanned load eccentricity, residual stresses on the steel profile. Load eccentricity was measured in the testing laboratory to overcome uncertainty. Although the residual stresses do not have significant impact on the behaviour of concrete encased columns due to concrete's strain capacity being the limiting factor for failure, residual stresses were modelled on the steel profile as initial stress fields following the residual stress definition of EN 1993-1-14. The distribution of residual stresses are illustrated in Figure 3.7.

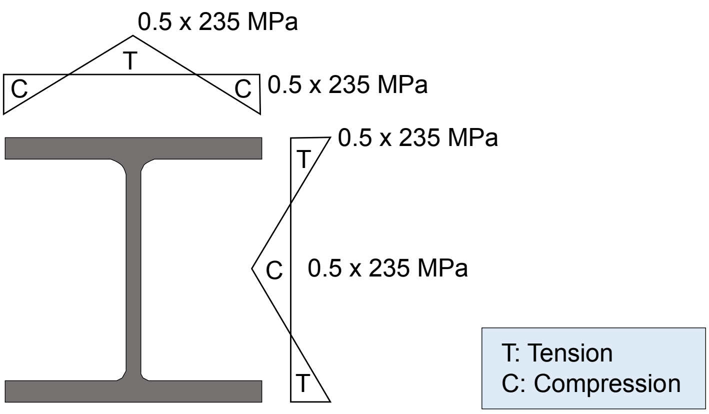


Figure 3.7. Residual Stress Distribution. [46]

Defining initial bow imperfections for individual member analysis of columns is an accepted approach to account for possible imperfections. However, the magnitude of this imperfection is not always known. For the calibration of test specimens, the initial bow imperfection was set as a variable parameter and adjusted for each specimen to come to the best curve fitting. In other words, every specimen had different bow imperfection magnitude. The way to apply these bow imperfections in abaqus is such that, firstly a linear buckling analysis is run on the specimens; the resulting eigenforms (buckling shapes) are exported to the main analysis as initial displacements. By the nature of the eigenvalue analysis, the buckling modes have a max displacement of unity. The scale applied to the displacement field then becomes the initial bow imperfection magnitude.

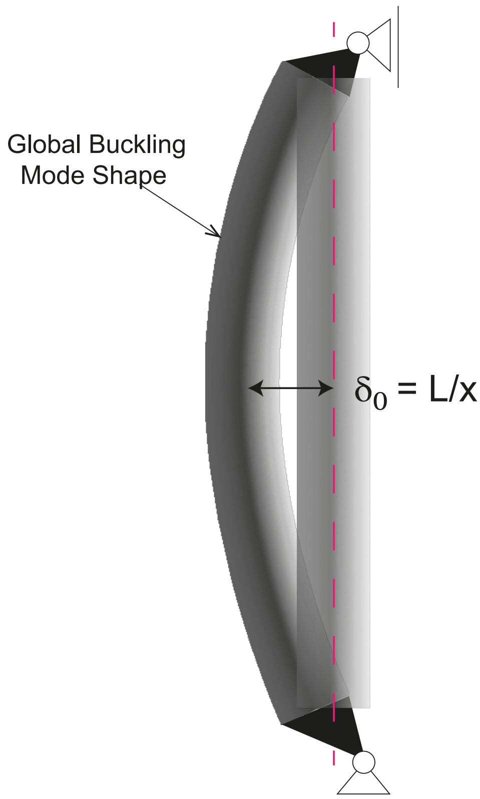


Figure 3.8. Exaggerated Initial Bow Imperfection

The created FE modelling methodology was previously used to simulate concrete encased steel slender column tests from literature listed in Table 1.1 accurately with results shown in Figure 3.9. Only concrete encased steel section tests were modelled where buckling length to section edge length/diameter ratio was greater than ten. This was to ensure geometrically nonlinear effects were present.

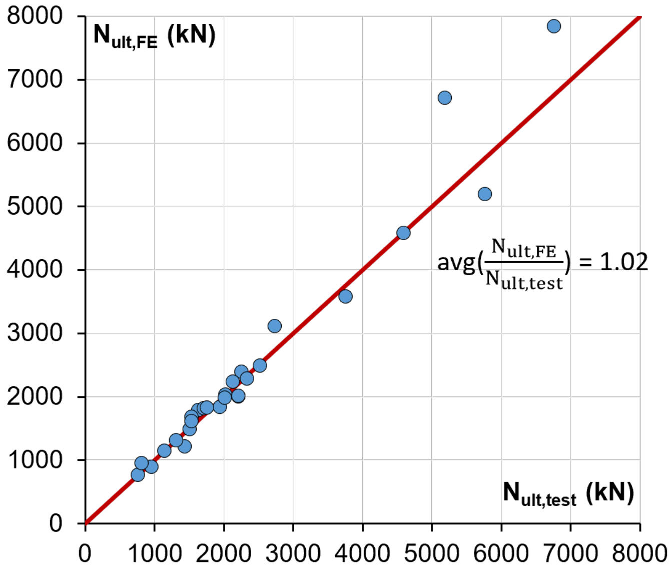


Figure 3.9. Calibrating FE Model with Tests from Literature

Table 3.3. Tests From Literature Used to Calibrate FE Model

Reference	Specimen	Width x Height (mm)	f_c (MPa)	f_a (MPa)	e (mm)	Bending Axis	$\frac{N_{ult,FEA}}{N_{ult,test}}$
Roik [5]	v11	280x280	43.8	232	160	Major	0.96
Roik [5]	v12	280x280	43.8	232	60	Major	1.13
Roik [5]	v13	280x280	43.8	232	100	Major	0.82
Roik [5]	v21	280x280	46.8	315	100	Major	1.02
Roik [5]	v22	280x280	37	315	160	Major	0.96
Roik [5]	v23	280x280	37	315	60	Major	0.99
Roik [5]	v31	280x280	40.7	227	100	Major	1.06
Roik [5]	v32	280x280	40.7	227	60	Major	1.06
Roik [5]	v33	280x280	39.3	227	160	Major	0.99
Roik [5]	v41	280x280	39.3	271	100	Major	1.07
Roik [5]	v42	280x280	42.2	271	160	Major	1.10
Roik [5]	v43	280x280	42.2	291	60	Major	1.16
Roik [5]	v111	280x280	40.1	300	100	Major	1.03
Roik [5]	v112	280x280	40.1	300	60	Major	0.97
Roik [5]	v113	280x280	40.1	300	0	Major	0.94
Roik [5]	v121	280x280	40.1	240	160	Major	0.91
Roik [5]	v122	280x280	40.1	240	200	Major	1.02
Roik [5]	v123	280x280	40.1	240	100	Major	1.02
Liew [6]	CES1	250x250	96	380	0	Minor	1.19
Liew [6]	CES2	240x320	96	380	0	Minor	1.12
Liew [6]	CES3	300x200	96	380	0	Minor	0.90
Kim [11]	C1	260x260	94	913	120	Major	1.00
Kim [11]	C2	260x260	94	913	60	Major	1.05
Kim [11]	C3	260x260	94	913	120	Major	1.06
Kim [11]	C4	260x260	94	913	120	Major	1.01
Kim [13]	C10	260x260	104	812	120	Major	1.05
Kim [13]	C11	260x260	104	812	120	Major	1.08

In Table 3.3, the highest overestimation is with 19% error and the underestimation with 18% error. These can be attributed to the lack of exact measurement of existing eccentricities, the existence of friction on end supports and therefore a different behaviour than simple support and the uncertainties in production of lab specimens.

3.1.5. Results and Analysis of Geometrical Imperfections

With the abovementioned model properties, all of the column specimens were simulated and the results are given in this section. Deflections shown on the load-midspan deflection curves are about weak axis for Specimen A1.1 and about strong axis for the rest.

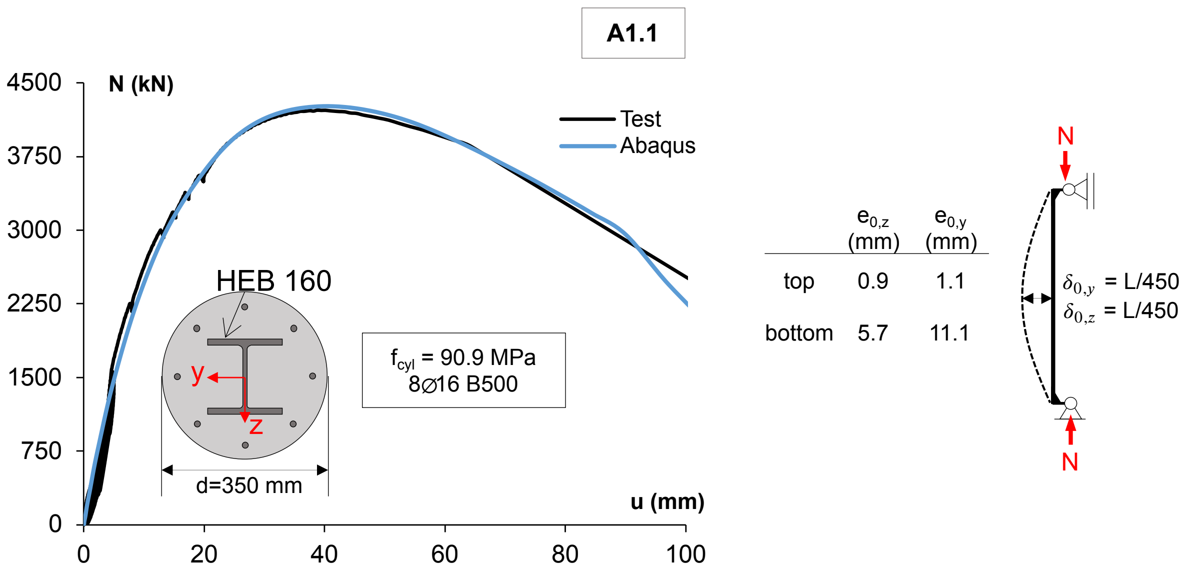


Figure 3.10. Test [1] & FEA Results for A1.1

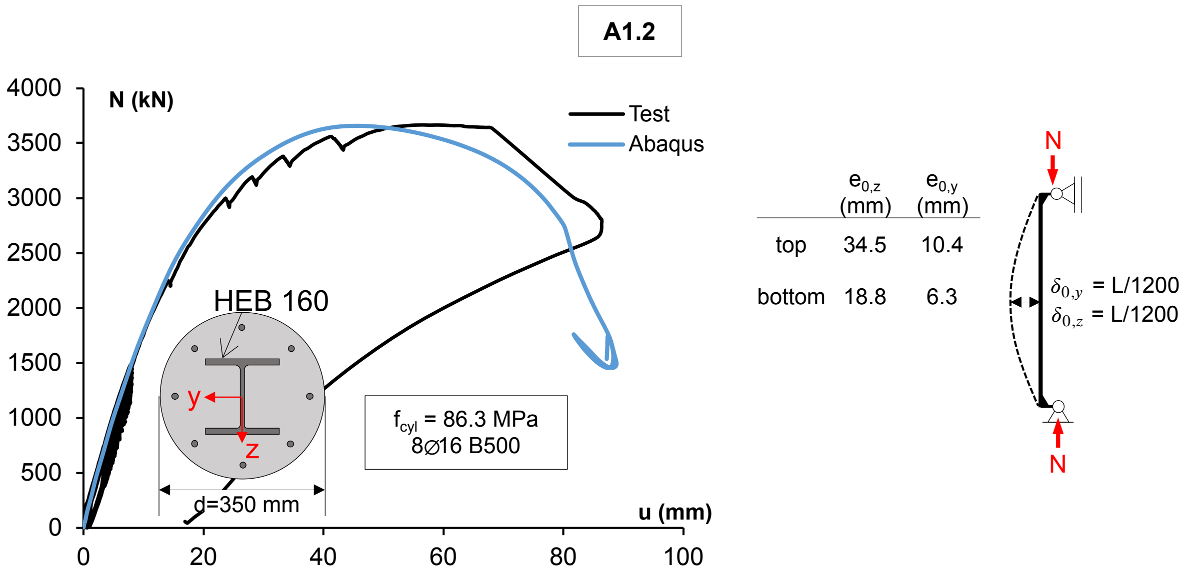


Figure 3.11. Test [1] & FEA Results for A1.2

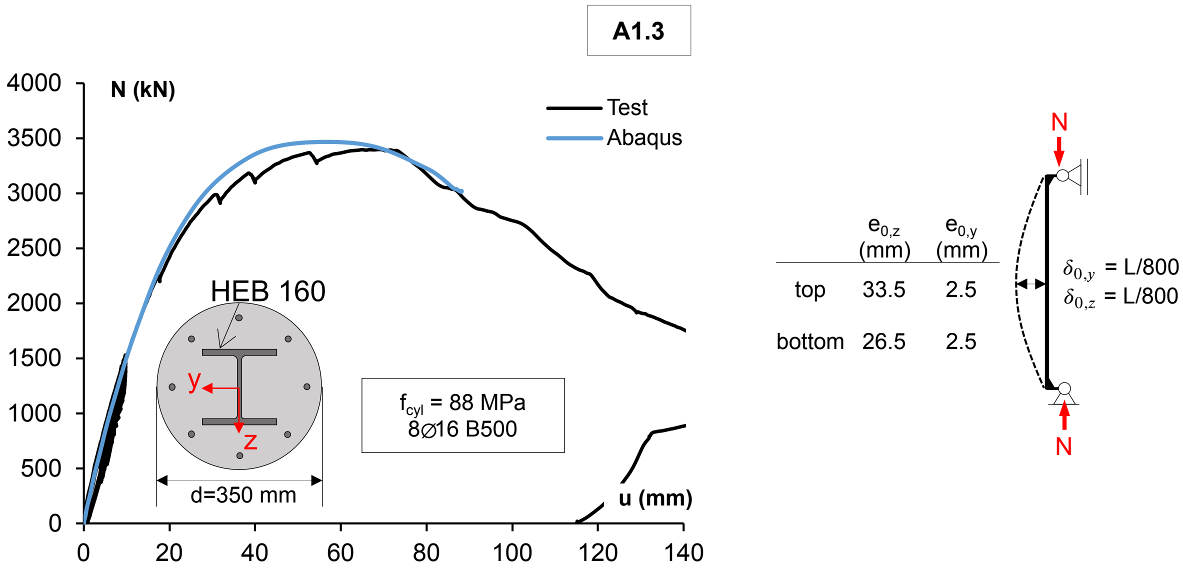


Figure 3.12. Test [1] & FEA Results for A1.3

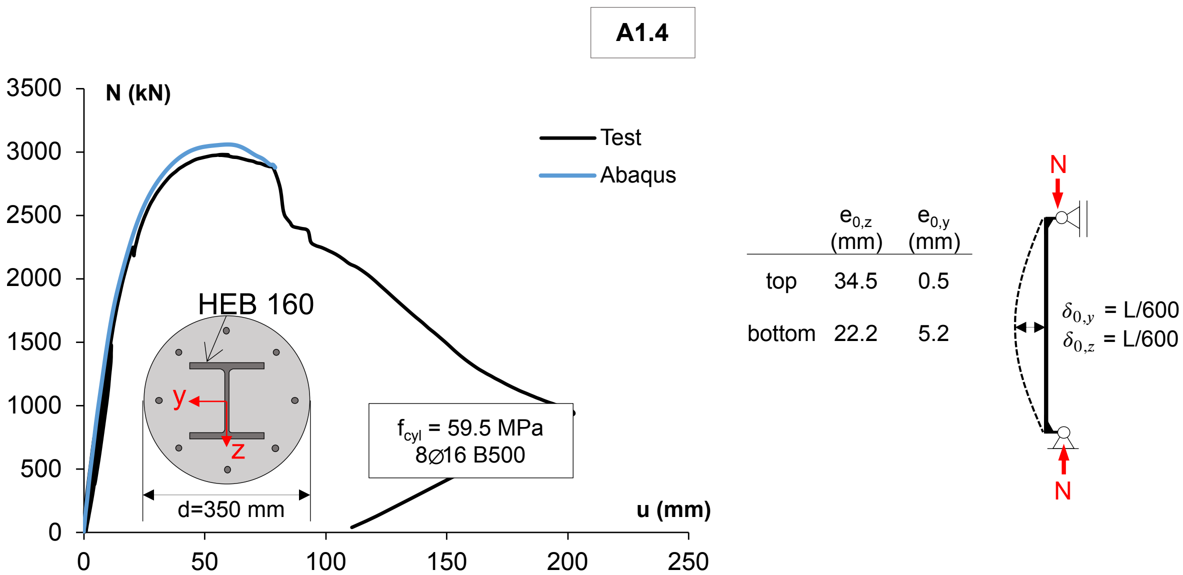


Figure 3.13. Test [1] & FEA Results for A1.4

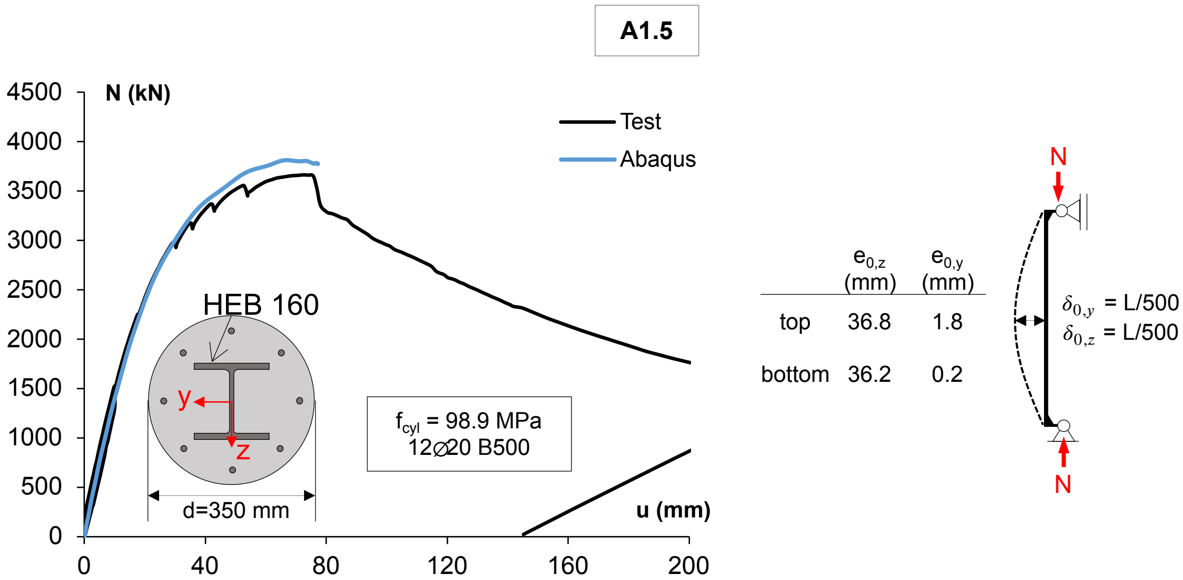


Figure 3.14. Test [1] & FEA Results for A1.5

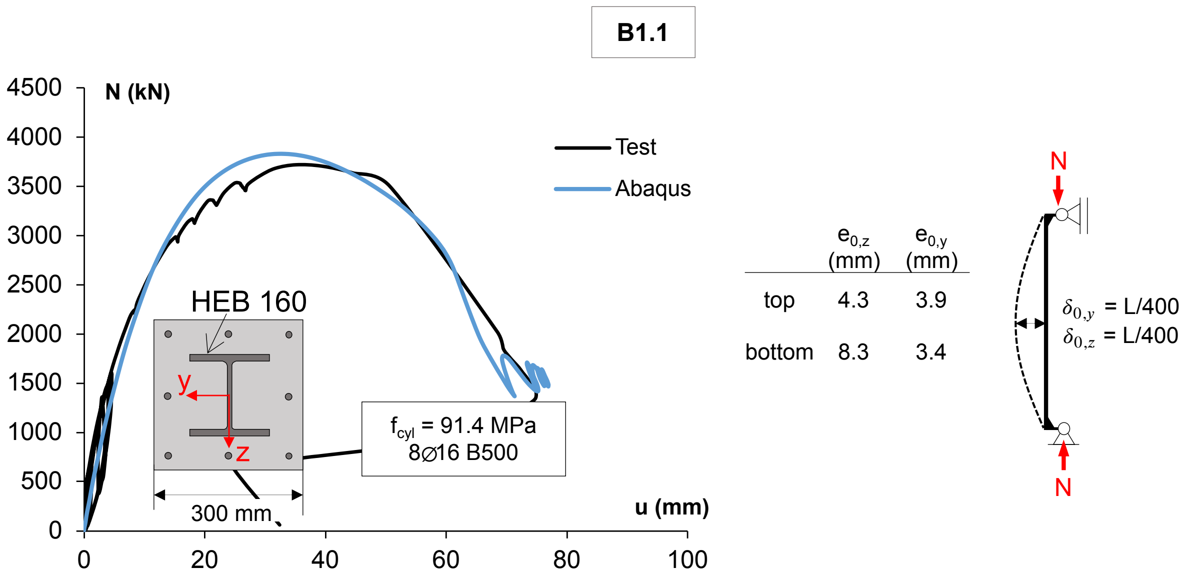
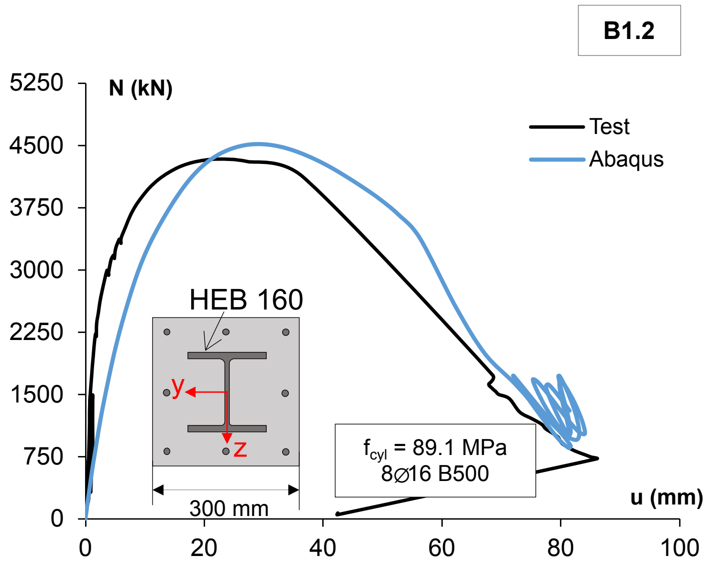


Figure 3.15. Test [1] & FEA Results for B1.1



	$e_{0,z}$ (mm)	$e_{0,y}$ (mm)
top	5.2	2.6
bottom	0.9	0.3

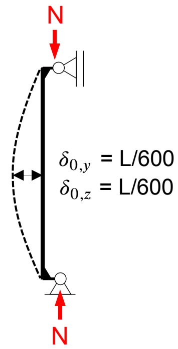
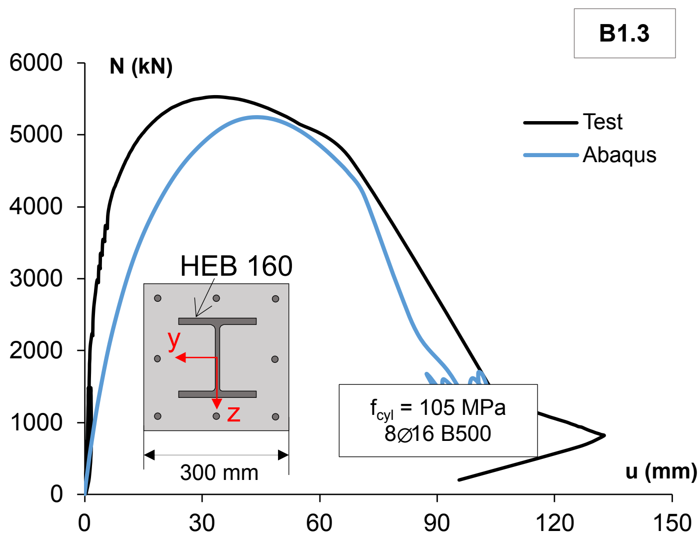


Figure 3.16. Test [1] & FEA Results for B1.2



	$e_{0,z}$ (mm)	$e_{0,y}$ (mm)
top	9.2	0.03
bottom	16.2	3

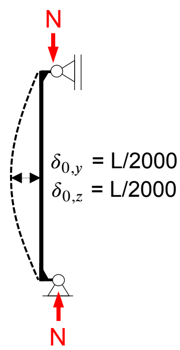


Figure 3.17. Test [1] & FEA Results for B1.3

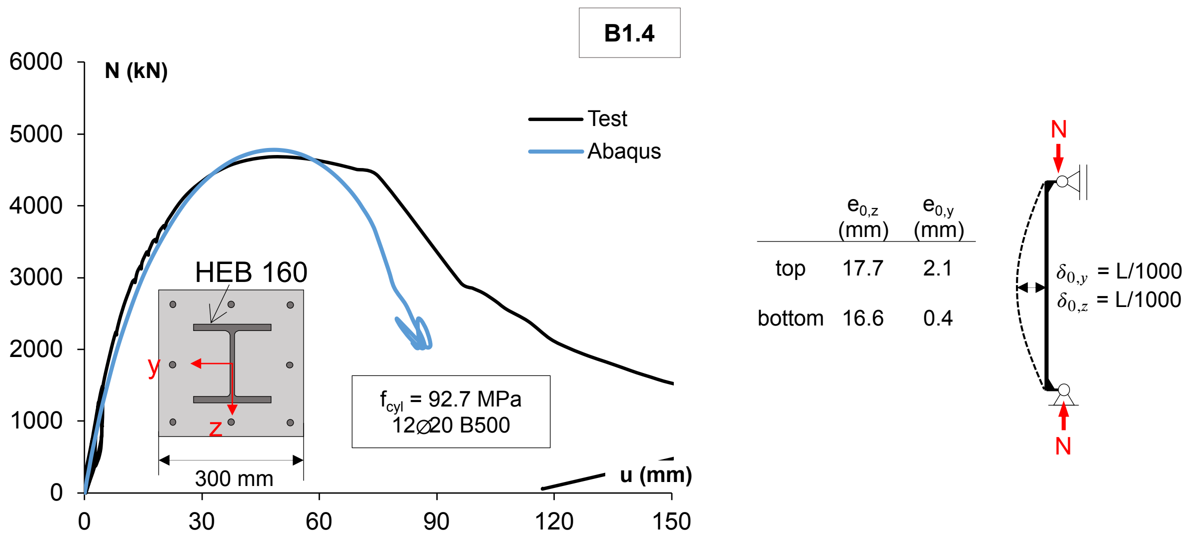


Figure 3.18. Test [1] & FEA Results for B1.4

Nine specimens were succesfully modelled with accurate initial stifness responses and ultimate force values. Comparison of ultimate forces are given in Table 3.1.5 between test and simulations. Specimens B1.2 and B1.3 showed worse validation results than others. This can be attributed to uncertainties of bow imperfection at direction perpendicular to the bending axis, placement of steel profile and reinforcement among other things. Overall, average ratio of Ultimate force in modelling to that of tests resulted as 1.015. Which is a very good accuracy considering all of the models had same properties except for initial bow imperfection values.

Table 3.4. Ratio of Ultimate Force from FEA to Test [1]

Specimen	L/x	Ultimate Force Abaqus to Test Ratio
A11	450	1.009
A12	1200	0.997
A13	800	1.021
A14	600	1.027
A15	500	1.040
B11	400	1.029
B12	600	1.040
B13	2000	0.949
B14	1000	1.020
Average		1.015

In Table 3.1.5, each specimen is listed with the bow imperfection used in the FEA model for the best fit. Although these values are not fixed and small changes in them can improve the ratio of ultimate force from FEA to test, to put them into perspective, they are presented with a bar chart in Figure 3.19. It is not intuitive to think with inverse values, but the chart with horizontal axis scaled linearly with inverse values show the dispersion from used imperfection values to the equivalent imperfections in EC4 for encased sections. The main cause of large equivalent imperfections is the notion that residual stresses reduce capacity. But it was shown if Figures 5.3 and 5.4 that its effect is not significant. The proposed initial bow imperfection L/600 is shown in the plot as well as the generally used imperfection L/1000 for steel columns and Eurocode 2's minimum load eccentricity L/400 to be considered for concrete columns.

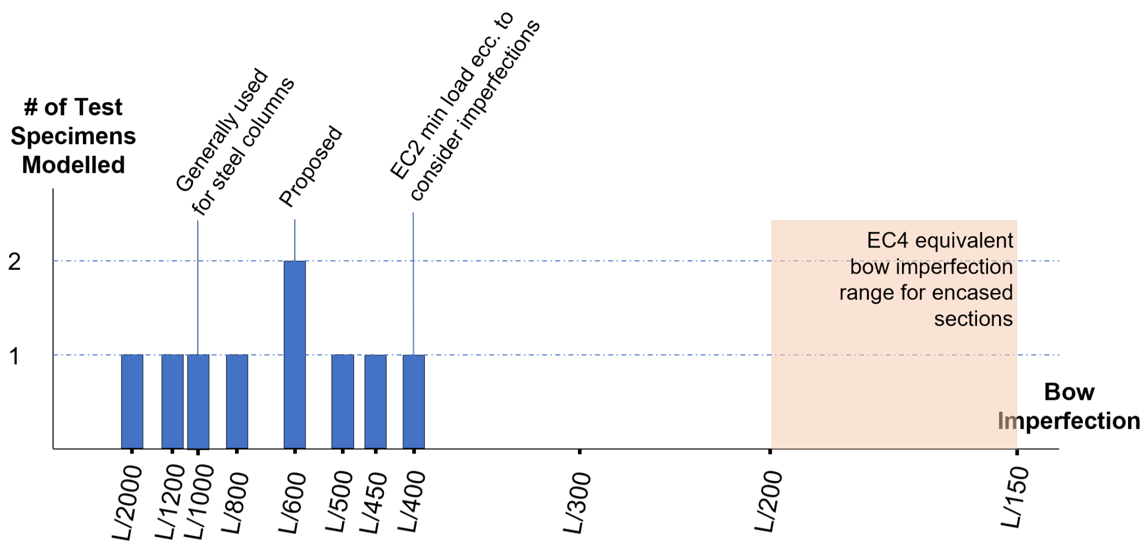


Figure 3.19. Used Initial Bow Imperfection for FEA vs Different Specifications

3.2. Modelling of Pushout Tests

The testing campaign reported in [2] presents push out tests for the same column sections used for slender column testing but with a length of 60 cm. Author was part of the testing campaign. Several tests are performed with and without shear studs. 9 specimens coded by K10.x had no shear studs and the only shear resistance source was the surface between concrete and steel profile. Other typologies were designed to test different shear stud arrangements. In this section, tests without shear studs are used for finite element analysis of push out tests to present an accurate surface modelling method for the interface between steel and concrete. In this chapter, the finite element analysis properties and results as well as load deflection curves are given. A hole was left under the steel profile to allow for vertical displacement as shown in 3.20.

Table 3.5. Pushout Specimens [2]

Typology	# of Headed Stud Rows	# of Specimens	Mean f_{cyl} (MPa)	Mean F_{ult} (kN)
K10 (Circular)	0	9	102.7	668

f_{cyl} is concrete cylinder compressive strength.
F_{ult} is maximum reached force in pushout test.

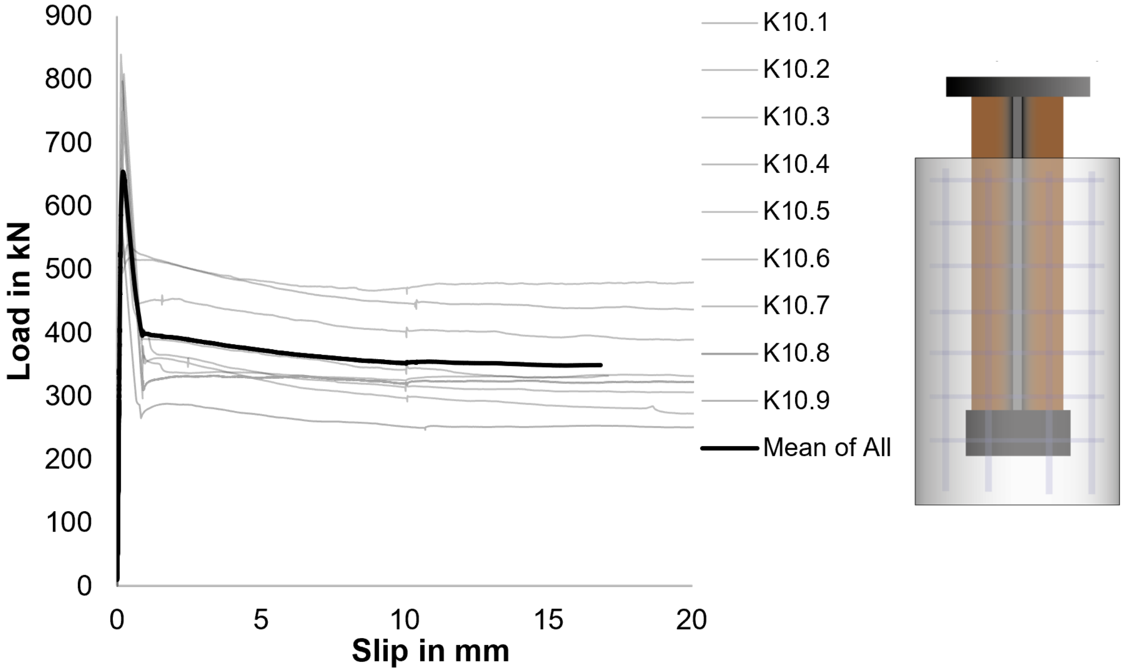


Figure 3.20. Load Slip Curves for K10, data from [2]

The K10 specimens with properties given above were modelled using Abaqus. As shown in Table 3.5, with each typology, multiple specimens were tested. These varied in concrete strengths but the broken down results for each test showed that the max force reached in tests did not correlate with concrete strength. This is an important observation that justifies use of mean concrete strength in modelling for each typology.

Load transfer mechanism of the specimens subject to this testing campaign have different contributors. These include

- Adhesion
- Friction
- Deformation of shear stud

Adhesion exists on contact surface between concrete and steel. It's highly dependent on surface properties of both materials and is of largest magnitude at the beginning of slip on the surface. Differently to friction, adhesion is present in all directions and is independent of the normal force. Friction is present between steel and concrete and is taken constant as 0.5 for all of the following FE models [3].

Due to the above explained existence of several contributors to the load transfer mechanism, the results from specimens K10 were modelled to capture the adhesive behaviour. K10 specimens consist only of concrete and steel profile without shear studs. This means the adhesive bond on the surface dictates their behavior. Therefore, initially an FE model was created for K10 specimens that could be taken as a basis for tests with shear studs. In this model, contact surface properties of adhesion were calibrated to give the same results with the tests. This calibration was done iteratively and only empirically to capture the results of tests with the created FE model.

Abaqus/Explicit was used as the FE analysis tool due to its abilities to solve problems with complex nonlinearities in material, geometry, contacts, interactions. It is a dynamic simulation framework but the tests to be modelled were static-monotonically loaded. It is a common practice to model static tests with Explicit analysis provided that the proportion of total kinetic to internal energy is monitored throughout the solution and does not exceed 5% for the most of the analysis time [44]. Explicit analysis also allows utilization of mass scaling which increases the mass of the materials modelled to decrease the solution time. This increases the dynamic effects in the solution and therefore makes the energy monitoring process even more crucial. "Smooth Step" was used as the time pattern with which the assigned deformation was applied in the simulation that starts with very low displacement increments and increases over time. Therefore, the dynamic affects do not accumulate from the beginning.

3.2.1. Material Properties

3.2.1.1. Concrete. For concrete, Eurocode 2 nonlinear stress-strain curve as well as strain at ultimate strength was taken as the material property. After sensitivity study and iterative simulations, it was realized that the slope and the length of the descending branch plays an important on behaviour of the simulation. Sudden drop of strength to zero as stipulated by Eurocode 2 for higher strength concrete has lead to sudden failure surface formation along the concrete specimen, which was not observed in testing. The mentioned sudden drop of strength is an attribute of plain concrete but the concrete under the shear studs in the push-out tests is actually highly confined. There are many models suggested in the literature for the confined stress-strain curve of concrete but they are given based on lateral reinforcement settings. In the push- out tests however, the concrete is confined in different directions by the steel profile web, flanges, stirrups and shear studs. It is not straightforward to revise the concrete material model to consider all of these confinement effects; therefore confinement effect was not involved in concrete stress-strain curve.

To overcome the sudden drop of concrete strength due to loss of adhesion, descending branch was taken linearly and the slope was determined iteratively to finally have the form shown in Figure 3.21. Concrete damaged plasticity was used as the material model and default parameters were used for plasticity properties as in Table 3.2. In the descending branch, compressive damage (stiffness degradation) was defined as $1 - \sigma/\sigma_{ult}$.

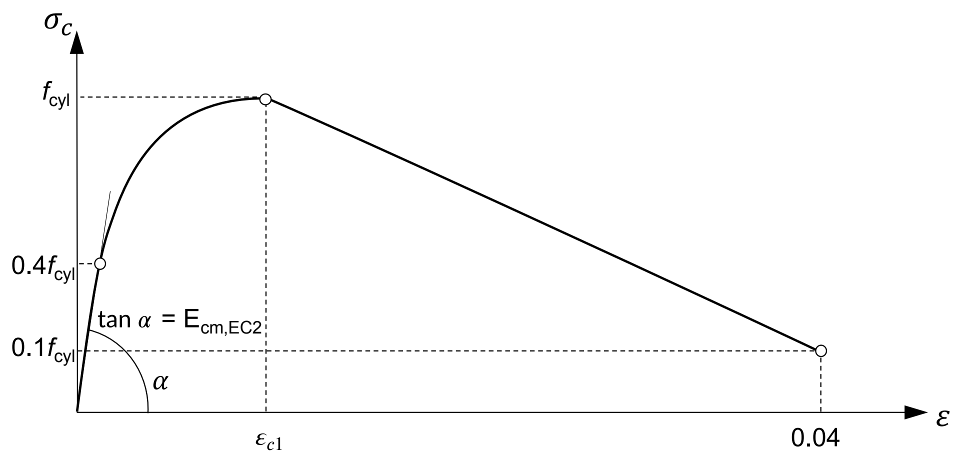


Figure 3.21. Concrete Stress Strain Curve Used in Modelling of Push-out Tests

<u>3.2.1.2. Steel.</u> For the structural steel, same material model as for column tests given in Figure 3.3 was used. For the reinforcement, material model in Figure 3.4 was adopted. It was observed from the FE analysis that the properties of the steel profile and reinforcement were not effecting the behaviour of the specimens.

<u>3.2.1.3. Cohesion.</u> The load slip behaviour of push-out tests can be divided in two parts. First, the stiff initial response where the cohesive property of the surface is resisting the slip, then the less stiff but ductile response where the shear studs are in action. To model the initial response, cohesive surface elements COH3D8 were used for the interface between concrete and steel profile. To calibrate the properties of the cohesive elements, K10 specimens were used as a reference since they had no shear studs and behaviour was purely based on interface. Three properties are important for modelling of cohesive elements:

- Initial stiffness

- Damage initiation
- Damage evolution

Initial stiffness is the stiffness of the surface resisting the initial loading. For pushout tests, only shear direction was important. This value was calibrated to fit curves of tests and simulations.

Damage initiation refers to the point at which initial high stiffness starts to degrade. For the calibration of pushout tests, it was defined throw shear strain.

Damage evolution defines the residual resistance of the cohesive surface after damage initiation starts. Abaqus has three options to define the damage evolution, these are linear, exponential and tubular. Linear and exponential damage evolution options drop the stress to zero following specified path but the load-slip curves from tests did not show the load to drop to zero even after large deformations. Therefore, tubular damage evolution was set with values being iteratively calculated to fit the load-slip curves of simulations to tests for K10 specimens. The values for damage evolution are given in Table 3.6.

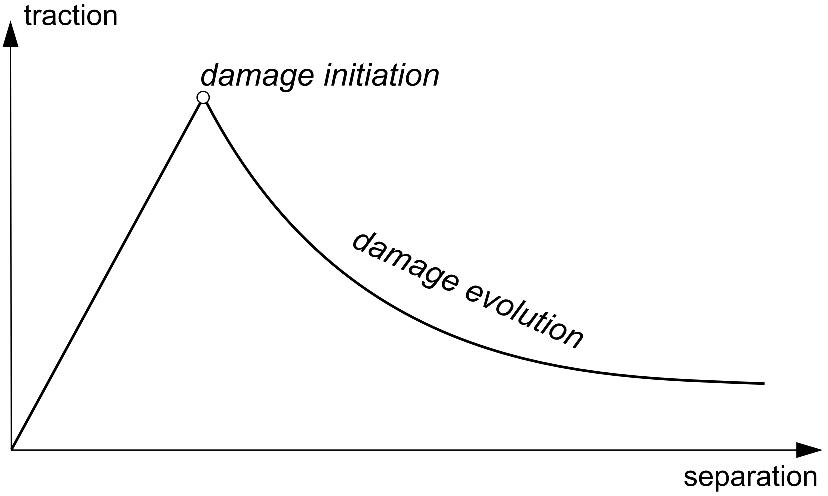


Figure 3.22. Cohesive Behaviour [44]

Table 3.6. Damage Evolution Parameters

Damage Variable	**Displacement**
0	0
0.0078	0.259
0.0181	0.4569
0.0341	0.6019
0.0565	0.7092
0.0884	0.7912
0.1400	0.8584
0.2017	0.9108
0.2699	0.9363
0.3441	0.9529
0.4247	0.9642
0.5117	0.9715
0.6053	0.9772
0.7034	0.9804
0.8105	0.9830
0.9210	0.9850
1.0409	0.9867
1.1627	0.9881
1.2938	0.9893
⋮	⋮
⋮	⋮
1.4295	0.9903
1.5695	0.9912
1.7174	0.9920
1.8678	0.9926
2.0233	0.9932
2.1728	0.9936
2.3253	0.9941
2.4825	0.9944
2.6497	0.9948
2.8145	0.9951
2.9800	0.9954
3.4800	0.9960
3.9800	0.9966
4.9800	0.9973
5.9800	0.9978
6.9800	0.9982
7.9800	0.9984
8.9800	0.9986
9.9800	0.9987

3.2.2. Mesh

Concrete, steel profile and shear studs were modelled by C3D8R volume elements. Reinforcement was modelled by B31 line elements. Cohesive surface was modelled by COH3D8 elements. Model showed nonsignificant sensitivity to mesh size.

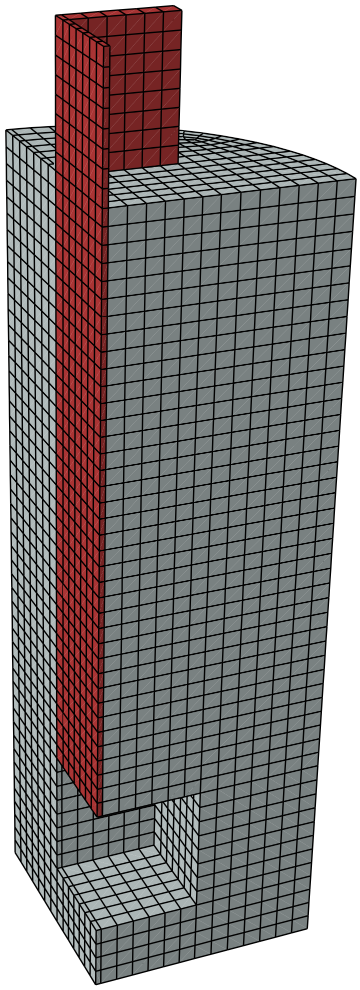


Figure 3.23. Mesh of Specimen K10

3.2.3. Results

3.2.3.1. K10. K10 typology had no shear studs and only the surface between concrete and steel resisted the forces. Test results were given on section x for individual and mean of all specimens. Mean load-deflection curve is used for the verification of FE model. As already given in Table 3.5, mean concrete strength was 102.7 MPa and mean ultimate force was 668 kN for K10 specimens. This model was used to calibrate the cohesive properties on the surface between steel and concrete. Many runs with varying damage properties resulted with best fit for the values given in Table 3.6 for damage evolution of cohesive surface. Damage initiation was defined through maximum shear strain "maxe" with a value of 0.002. Initial stiffness of the cohesive surface had a value of 52 MPa which was also determined iteratively. With the previously given material properties and above given cohesive surface properties, the load-deflection relationship obtained compared with the test result is given in Figure 3.24.

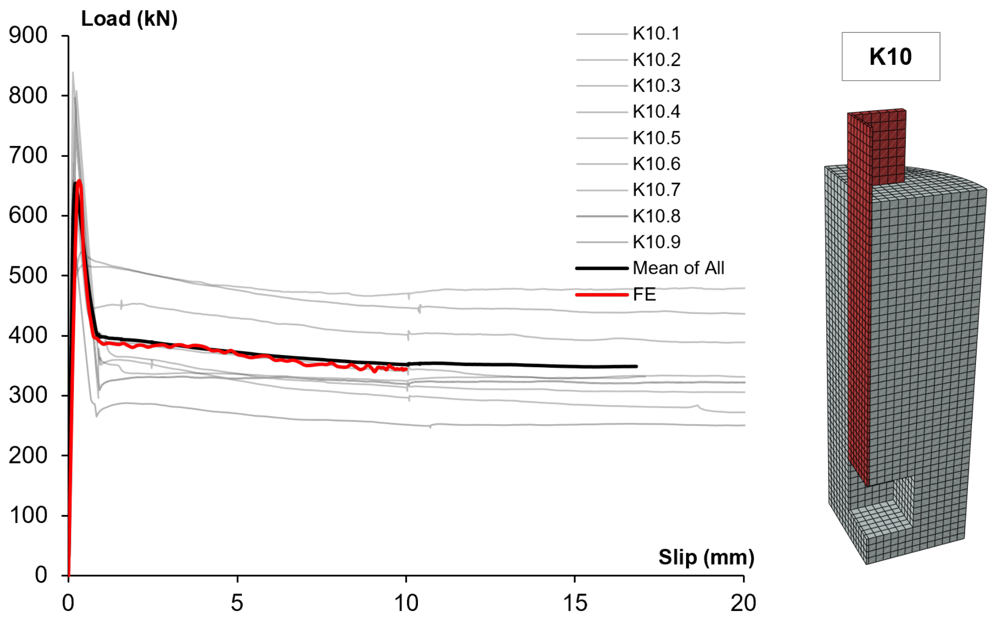


Figure 3.24. Test [2] vs FEA for K10

This chapter presents a methodology to numerically model push out tests whose behaviour is governed by contact surface without shear studs. The model was not developed to be used for tests with studs since there was no test info on shear studs reported in [2]. It is shown that the proposed surface property modelling approach is accurate for the tests considered. The friction coefficient for concrete-steel surfaces taken as 0.5 has also been confirmed in this chapter by accurately capturing test behaviour with it. Therefore, the findings in this chapter can be used as a starting point by other researchers in order to successfully simulate surface behaviour in push-out tests of steel and concrete.

4. SECOND ORDER (P-delta) EFFECTS ON MODELLED TESTS

4.1. Introduction

For slender columns failing with global buckling, second order effects and moment amplification in critical section are the main drivers of failure. Design standards, independent of being for steel, concrete or composite structures, require the designer to consider amplification of action effects for slender columns. Different approaches from different design codes are detailed in Chapter 1. In this chapter, data from the modelled columns in the previous chapter is used to check the approach of Eurocode 4 for calculating second order effects. The effective flexural stiffness $EI_{eff,II}$ used with initial bow imperfections from Eurocode 4's simplified method to compare internal moments from tests and calculations. Afterwards, different bow imperfections calibrated from tests in previous chapter replaced those of Eurocode 4. In the following sections, it will be shown that these calculations highly overestimate internal moments. Overestimation will be shown to be much more significant for biaxial bending check of Eurocode 4. Finally, the background of $EI_{eff,II}$ and Eurocode 4's initial bow imperfections is presented. The conclusion is made for possible reasons for highly conservative calculations. The interaction curves are created with mean (nominal) material stress-strain curves. For concrete the slightly modified as in Figure 3.2.

4.2. Internal Moment Calculation

In Eurocode 4 second order effects are considered by calculating internal moment based on end moments and normal force by applying Equation 4.1 as presented below. This equation takes into account equivalent imperfections and a reduced flexural stiffness $EI_{eff,II}$. The test results will be interpreted to see how well Equation 4.1 used with equivalent bow imperfections and $EI_{eff,II}$ captures the empirical behaviour.

$$M_{Ed} = \frac{M_{Ed,Im} + \beta_M M_{Ed,Em}}{1 - N_{Ed}/N_{cr,eff}} \tag{4.1}$$

where:

$M_{Ed,Em}$ is the maximum column end moment

$M_{Ed,Im}$ is the maximum first order moment within the length of column including effect of imperfections

β_M is equivalent moment factor depending on moment ratio at the end of columns. It is equal to 1.1 when the end moments are equal.

$N_{cr,eff}$ is the critical buckling force calculated using $EI_{eff,II}$ which is given below.

$$EI_{eff,II} = 0.9\left(E_a I_a + E_s I_s + 0.5 E_{c,eff} I_c\right) \tag{4.2}$$

$$E_{c,eff} = \frac{E_{cm}}{1 + (N_{G,Ed}/N_{Ed})\,\varphi_t}$$

where,

φ_t is the creep coefficient from Eurocode 2.

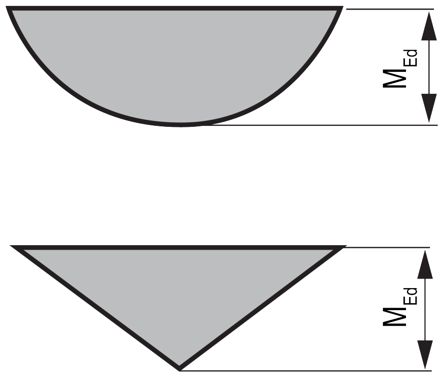
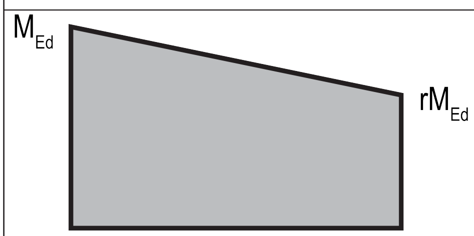
N_{Ed} is the total design normal force

$N_{G,Ed}$ is the permanent design normal force

definitions of $N_{Ed}, E_a, I_a, E_s, I_s, E_{c,eff}, I_c$ are given in Section 2.1.1.2.

β is equivalent moment factor given in Table 4.1.

Table 4.1. Equivalent Moment Factor from Eurocode 4

Moment distribution	Moment factors β	Comment
	First-order bending moments from member imperfection or lateral load: $\beta = 1.0$	M_{Ed} is the maximum bending moment within the column length ignoring second-order effects
 $-1 \leq r \leq 1$	End moments: $\beta = 0.66 + 0.44r$ but $\beta \geq 0.44$	M_{Ed} and rM_{Ed} are the end moments from first-order or second-order global analysis

Equivalent initial bow imperfections to represent geometric and structural imperfections are also to be taken into account when calculating second order bending moment on the section. For encased rectangular section composite columns, Eurocode 4 requires equivalent initial bow imperfection to be taken as L/200 for bending about strong axis and L/150 for bending about weak axis, L being the column length. The axis about which the test specimens shall be checked is not trivial to decide. In the considered tests [1], the loading machine bearing was able to rotate in any direction and the centroid of the bearing to the centroid of the columns at top and bottom were not aligned. This is shown in Figure 4.1. This means the columns were loaded under biaxial fashion although one of the principal axes always had a higher load eccentricity. Eurocode 4 has different requirements when it comes to design for uniaxial bending vs. biaxial bending. The designer shall consider biaxial bending and initial imperfections in both directions when the axis of failure is not clear. In case of biaxial bending, design to capacity ratios for both strong and weak axes are to be added linearly and the result shall be less than 1.0. This gives highly conservative results and will be presented for the test specimens.

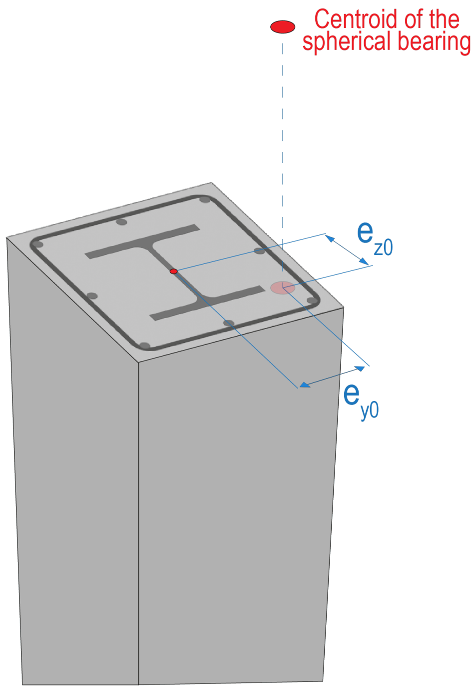


Figure 4.1. Support Eccentricity for Tests Presented in [1]

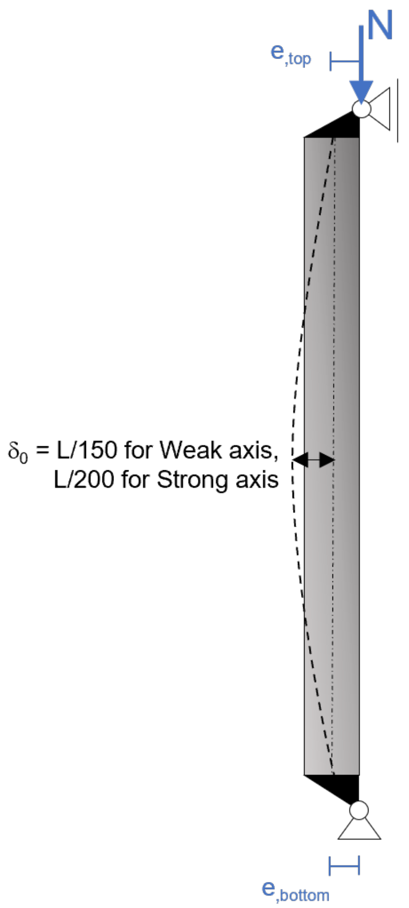
The values of load eccentricities are given in Table 4.2. The planned buckling direction was about weak axis for A1.1 and about strong axis for the rest and the load-deflection curves therefore contain the deflection in weak axis direction for A1.1 and strong axis direction for the rest. However, all columns failed in mixed mode. The scenarios for design of the columns about strong axis only, weak axis only and for biaxial bending will be considered and compared for each specimen. In the interaction curves, $N_{Test,100\%}$ represents the maximum force reached in the test for that specimen, also, lower load points and internal bending moment for those points calculated by Equation 4.1 are presented. For each load point, normal force and end moments are input to Equation 4.1 and if the resulting M_{Ed} fall outside interaction curve, the text is written in red. $M_{Ed,Em}$ and $M_{Ed,Im}$ are calculated as in Figure 4.2.

Table 4.2. Column Support Eccentricities [1]

Specimen	$e_{z0,top}$ (mm)	$e_{y0,top}$ (mm)	$e_{z0,bottom}$ (mm)	$e_{y0,bottom}$ (mm)
A1.1 (Circular)	0.9	1.1	5.7	11.1
A1.2 (Circular)	34.5	10.4	18.8	6.3
A1.3 (Circular)	33.5	2.5	26.5	2.5
A1.4 (Circular)	34.5	0.5	22.2	5.2
A1.5 (Circular)	36.8	1.8	36.2	0.2
B1.1 (Square)	4.3	3.9	8.3	3.4
B1.2 (Square)	5.2	2.6	0.9	0.3
B1.3 (Square)	9.2	0.03	16.2	3
B1.4 (Square)	17.7	2.1	16.6	0.4

4.2.1. Approach 1

Initial bow imperfections are based on Eurocode 4 specification for rectangular encased columns. Namely, L/150 for weak axis bending and L/200 for strong axis bending. For the biaxial interaction, linear combination as in Eurocode 4 is adopted.



$$M_{\mathrm{Ed,Em}} = \mathrm{N} \times \max(\mathrm{e_{top}}, \mathrm{e_{bottom}})$$

$$M_{\mathrm{Ed,Im}} = \mathrm{N} \times \delta_0$$

Figure 4.2. Inputs for Calculation of Second order Internal Moment

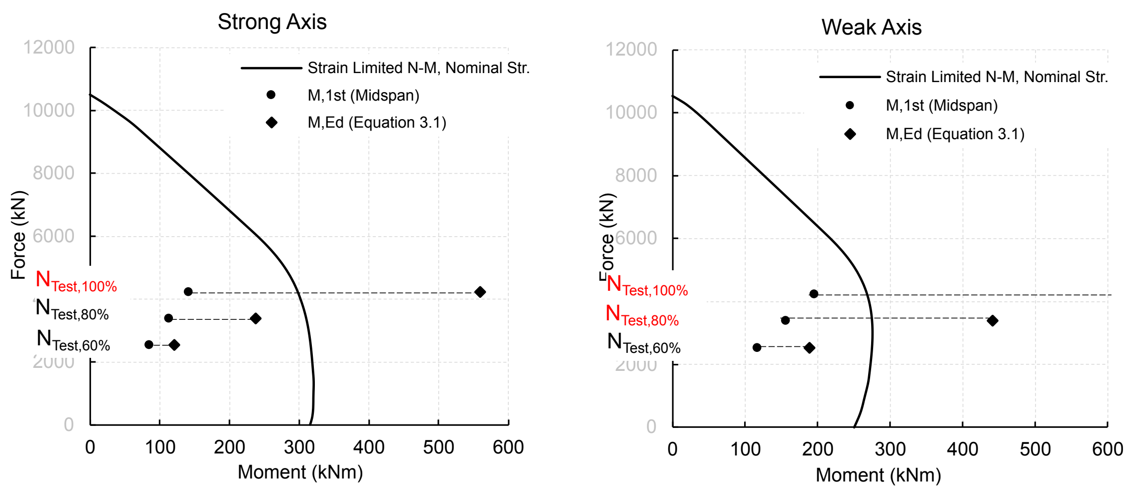


Figure 4.3. Interaction curve for A1.1 and 1^{st} order and 2^{nd} order moments

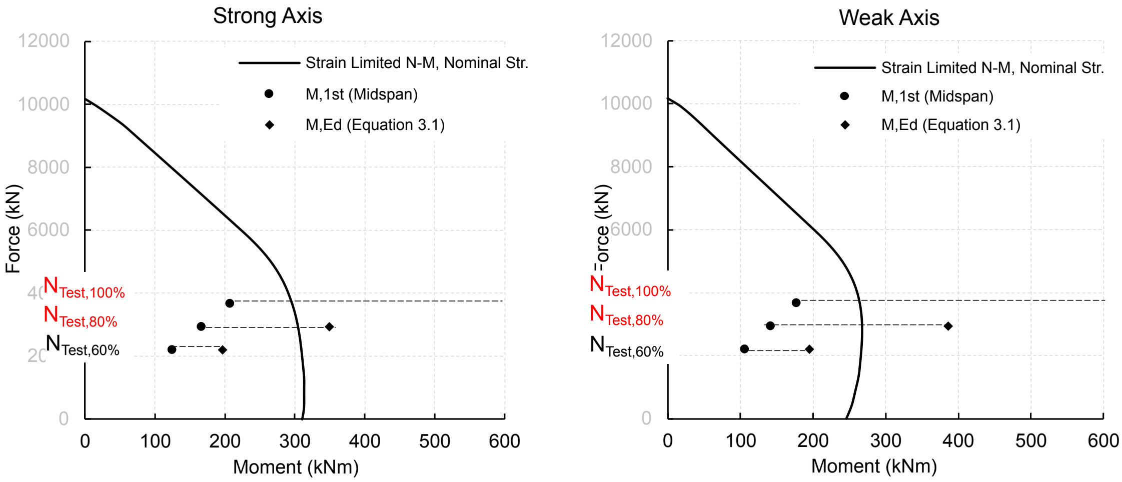


Figure 4.4. Interaction curve for A1.2 and 1^{st} order and 2^{nd} order moments

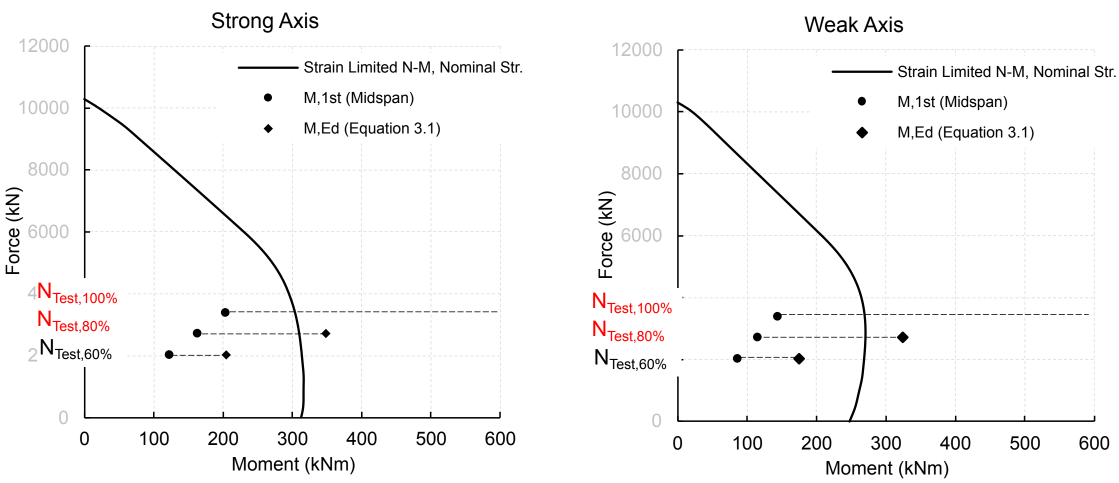


Figure 4.5. Interaction curve for A1.3 and 1^{st} order and 2^{nd} order moments

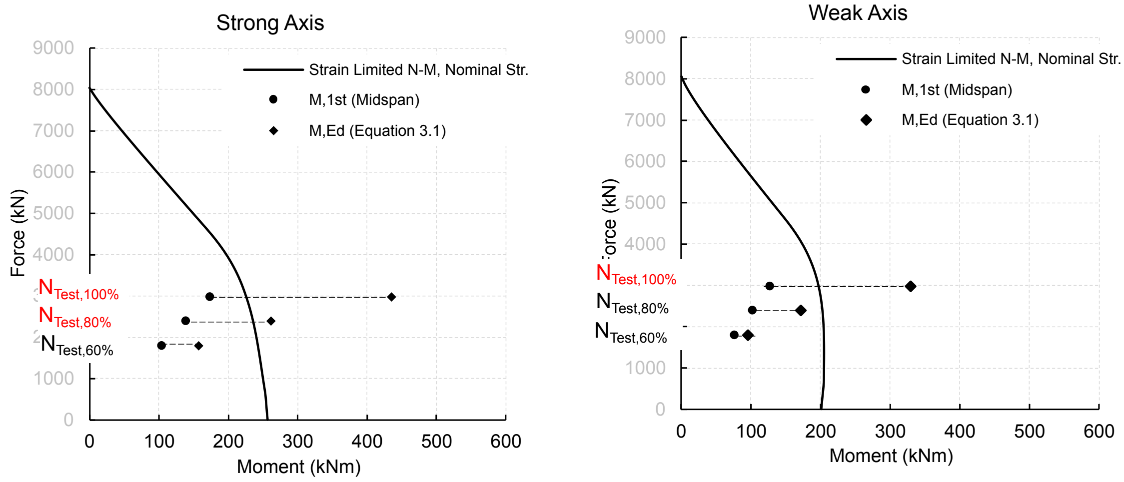


Figure 4.6. Interaction curve for A1.4 and 1^{st} order and 2^{nd} order moments

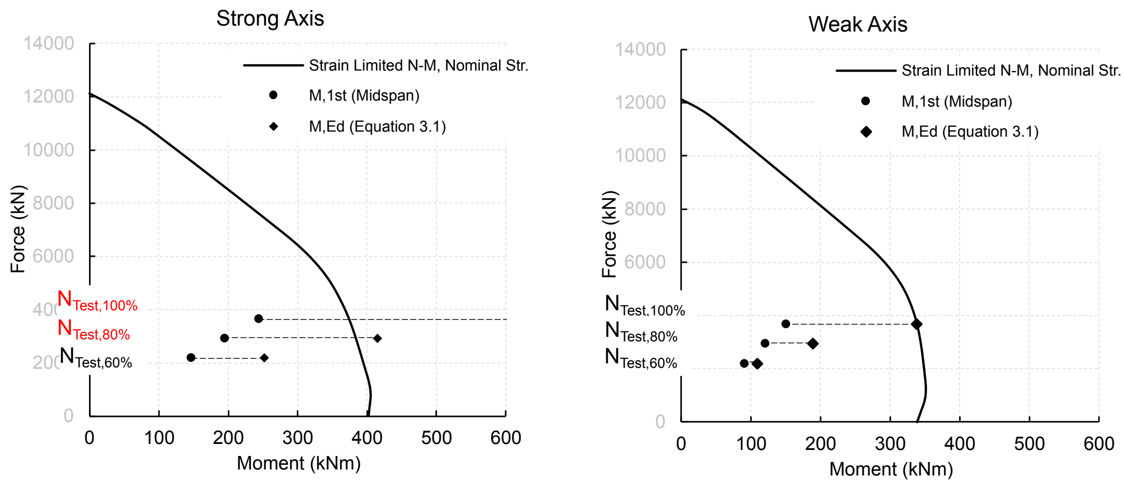


Figure 4.7. Interaction curve for A1.5 and 1^{st} order and 2^{nd} order moments

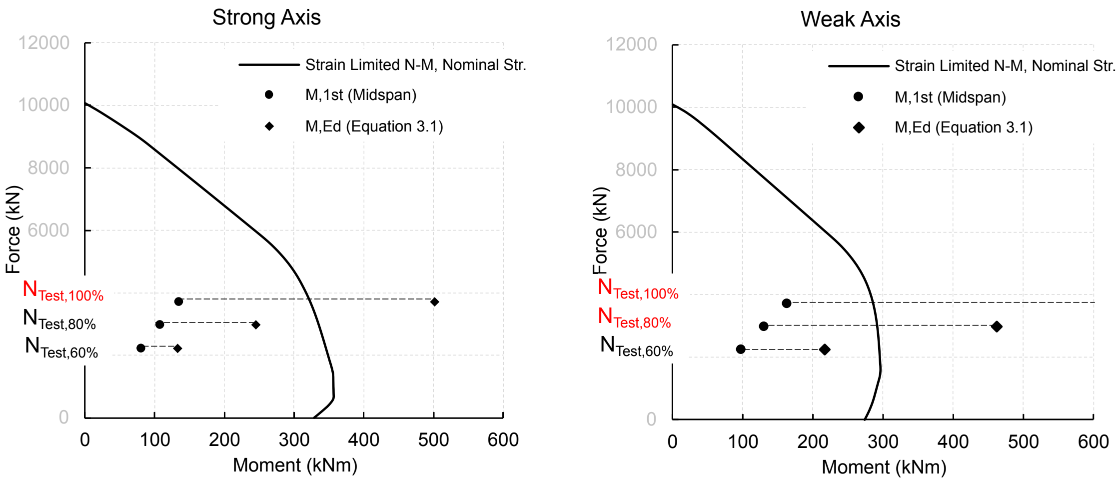


Figure 4.8. Interaction curve for B1.1 and 1^{st} order and 2^{nd} order moments

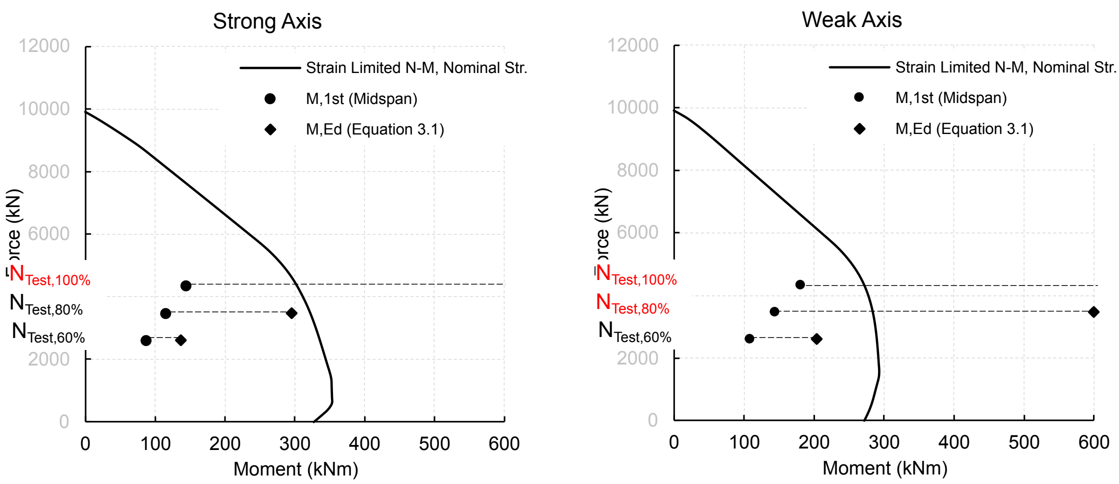


Figure 4.9. Interaction curve for B1.2 and 1^{st} order and 2^{nd} order moments

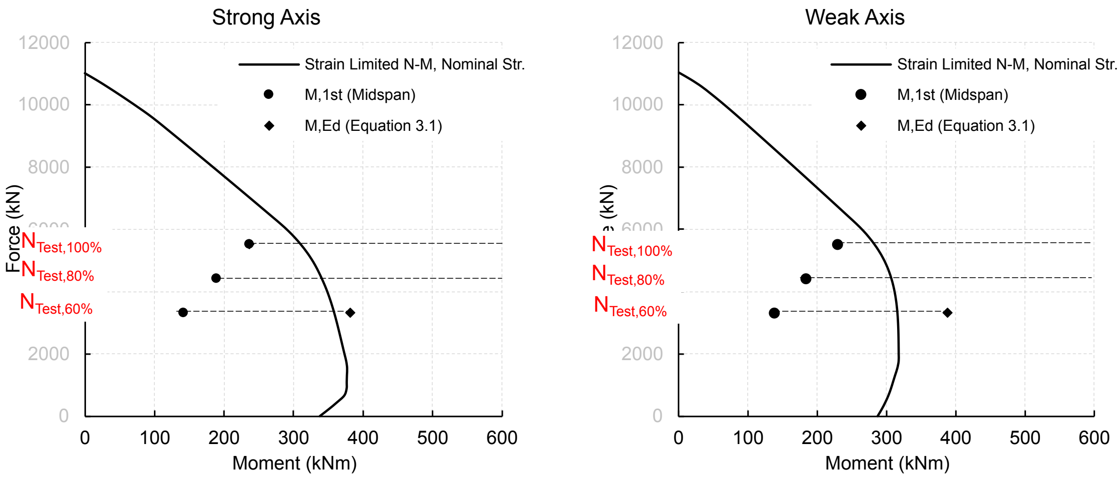


Figure 4.10. Interaction curve for B1.3 and 1^{st} order and 2^{nd} order moments

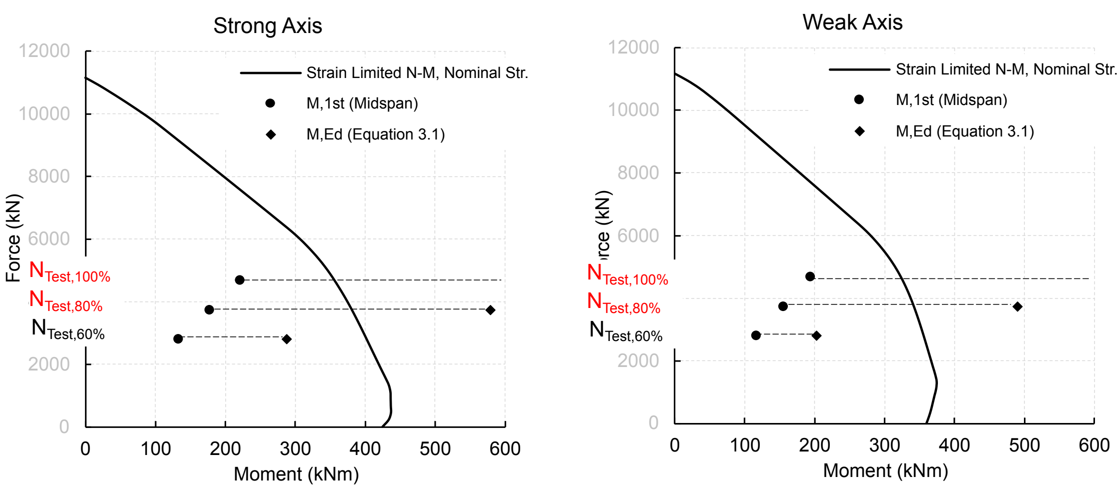


Figure 4.11. Interaction curve for B1.4 and 1^{st} order and 2^{nd} order moments

Figures 4.3 to 4.11 show the strain-limited interaction curves for all specimens with nominal material strengths. Round points show the first order internal bending moment at mid-span and diamond shaped points show the output of Equation 4.1 for each load level. All of second order internal moment values M_{Ed} by application of moment amplification Equation 4.1 gave very conservative results at the 100% of test loading level. Many of the specimens did not reach 80% utilization considering the test capacity. It was even lower than 60% for specimen B1.3. One significant observation is that for B1.1 and B1.2, although the load eccentricities were higher for buckling about strong axis, the interaction curve for weak axis showed even lower utilization. This shows design only about strong axis can result with non-conservative results.

With the light of this observation, it seems crucial to do the biaxial bending check for each column. As mentioned previously, Eurocode 4 requires the utilization for weak and strong axes to be added and results be less than 1.0. Obviously from mentioned figures, this will yield overconservative results. This is outlined in Table 4.3.

Table 4.3. (Biaxial Cross Section Actual Bending Moment)/(Eurocode 4 Resistance for Biaxial Bending)

	Load Level (%)				
Specimen	20	40	60	80	100
A1.1	1.2	1.3	1.8	3.0	10.3
A1.2	1.5	1.8	2.3	3.2	5.8
A1.3	1.5	1.7	2.2	2.9	4.4
A1.4	1.4	1.5	1.9	2.4	3.6
A1.5	1.2	1.3	1.6	2.0	2.8
B1.1	1.1	1.4	1.9	2.9	6.6
B1.2	1.0	1.2	1.8	3.8	3.9
B1.3	0.3	0.8	2.3	4.9	-*
B1.4	1.2	1.5	2.1	3.7	14.4

$*$ Test load exceeded N_{cr} therefore internal moment can't be calculated

The results are not surprising but very significant. Eight out of 9 columns would not even reach 20% of the ultimate force reached in test if they were designed by Eurocode 4 for biaxial bending based on linear interpolation. Not to forget, the calculations were done using nominal strength of materials, no partial safety factors were used. With partial safety factors, the utilization would decrease even further. Without doubt, Eurocode 4's method to combine biaxial bending must be updated. Simultaneous occurrence of bending about strong and weak axes do increase the stresses on the section but their combination is not one to one. This is explained in Figure 4.12 and will be investigated in Section 7. In the figure the red hatched area shows the non-utilized resistance of a column section. The size of this area depends on the section typology. The loss of utilization is highest when the combination of design moments about y and z axes meet near the center of hypotenuse in the figure.

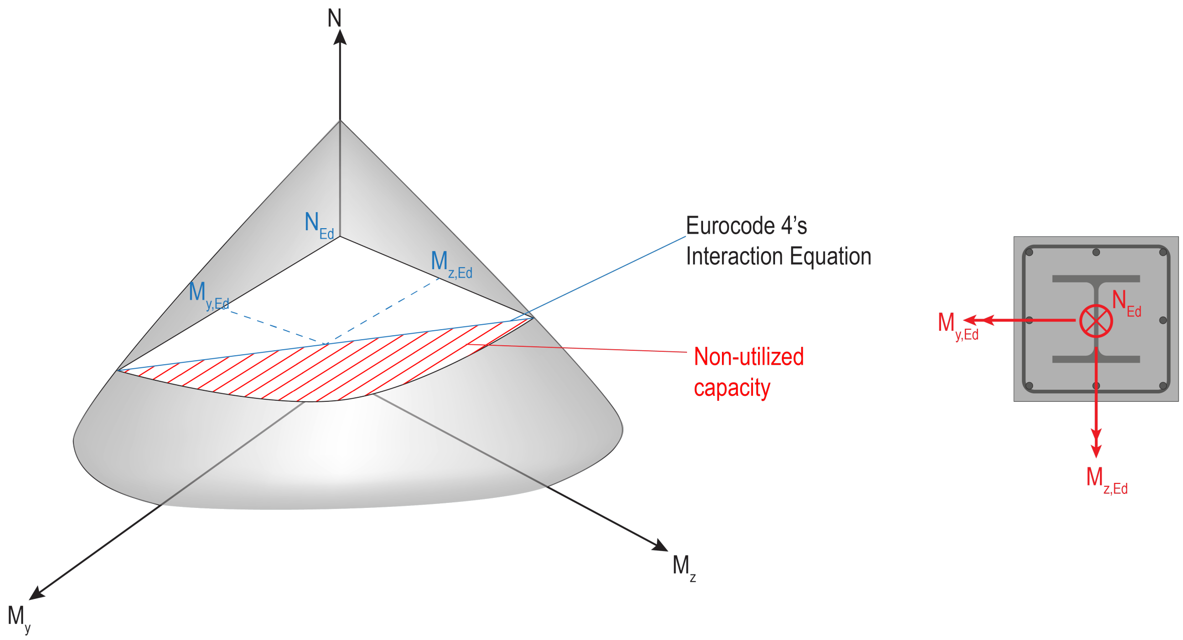


Figure 4.12. Biaxial Interaction Surface

4.2.2. Approach 2

After obtaining overconservative results from the previous approach, where initial bow imperfections and effective flexural stiffness were taken from Eurocode, for this approach, imperfections are taken from finite element calibrations. Effective flexural stiffness is taken again from Eurocode. For the biaxial interaction, linear approach same as Eurocode will be adopted.

Specimen	w_0
A1.1	450
A1.2	1200
A1.3	800
A1.4	600
A1.5	500
B1.1	400
B1.2	600
B1.3	2000
B1.4	1000

Imperfection values from test calibration

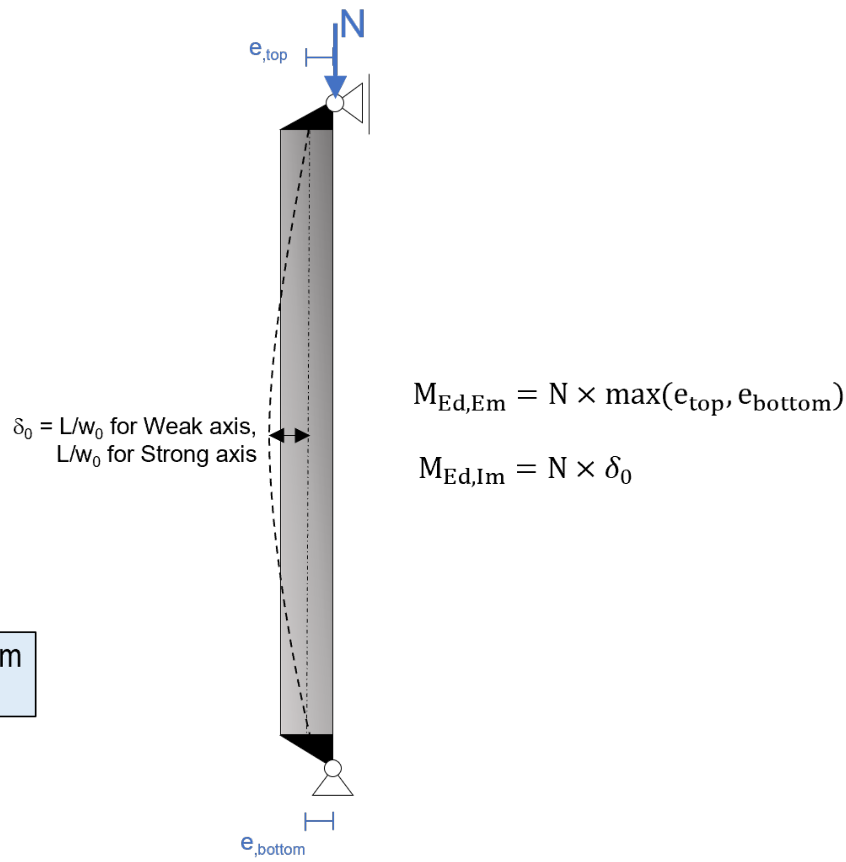


Figure 4.13. Inputs for Calculation of Second order Internal Moment

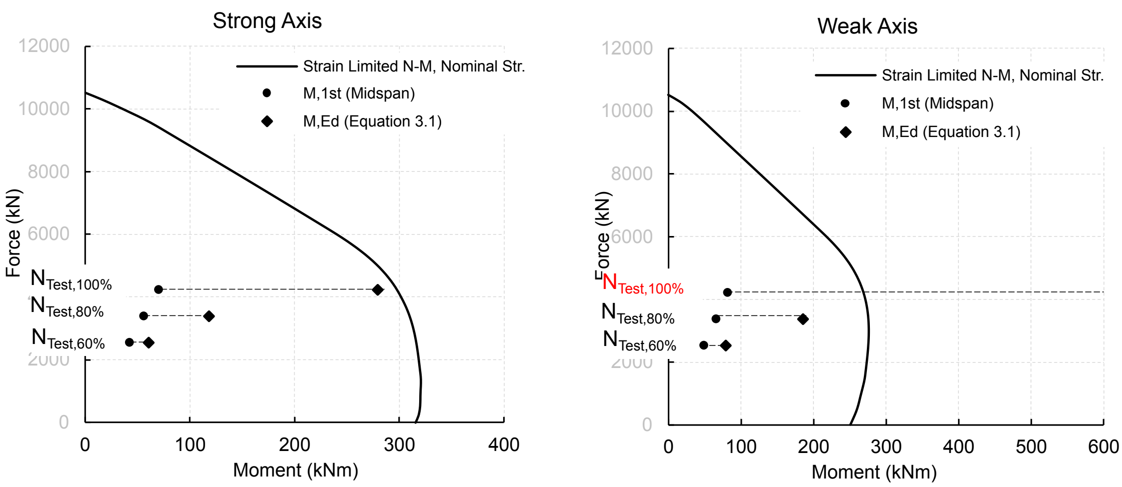


Figure 4.14. Interaction curve for A1.1 and 1^{st} order and 2^{nd} order moments

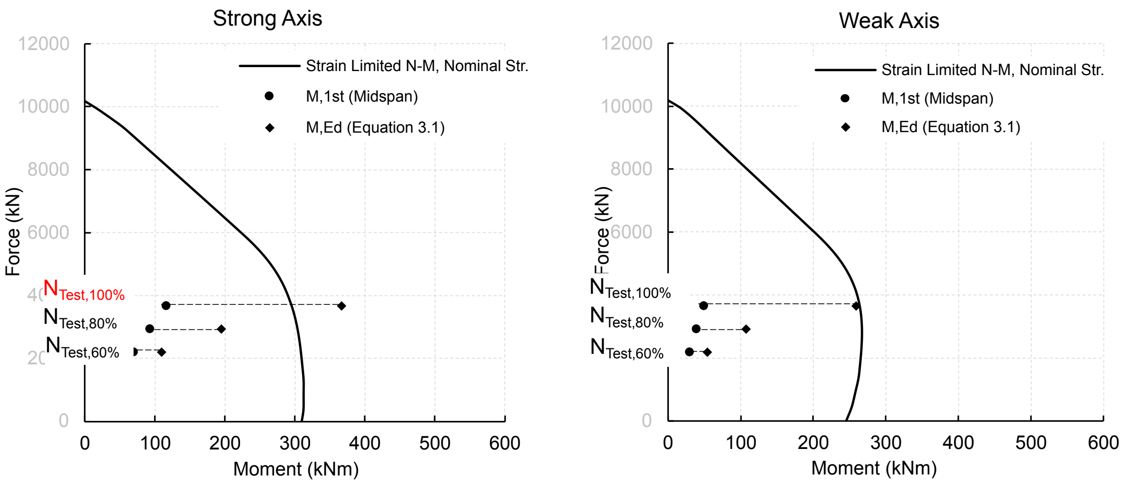


Figure 4.15. Interaction curve for A1.2 and 1^{st} order and 2^{nd} order moments

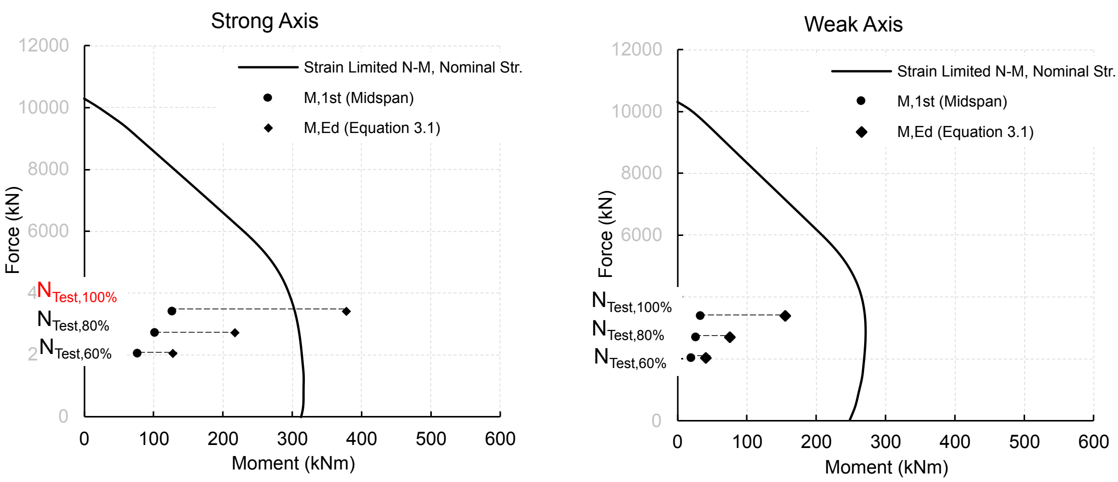


Figure 4.16. Interaction curve for A1.3 and 1^{st} order and 2^{nd} order moments

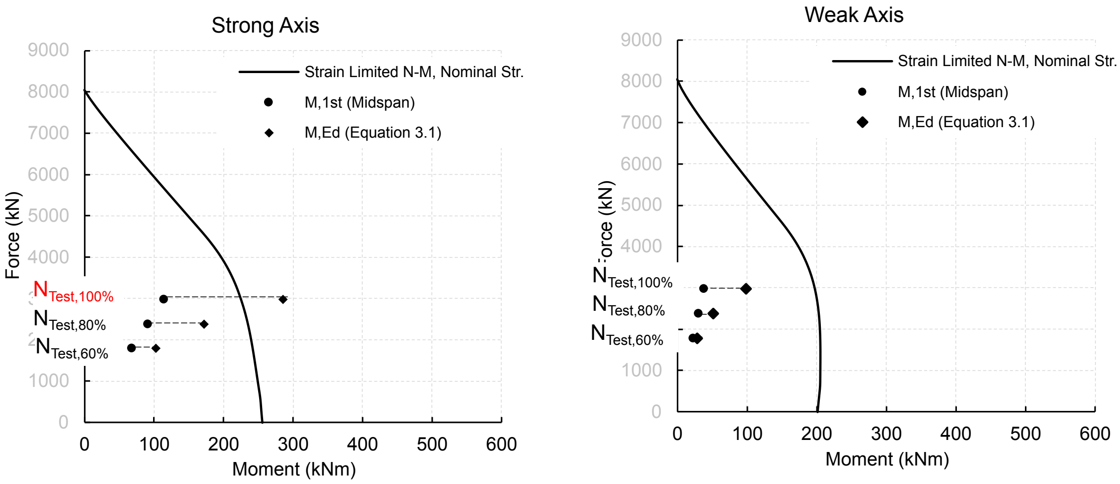


Figure 4.17. Interaction curve for A1.4 and 1^{st} order and 2^{nd} order moments

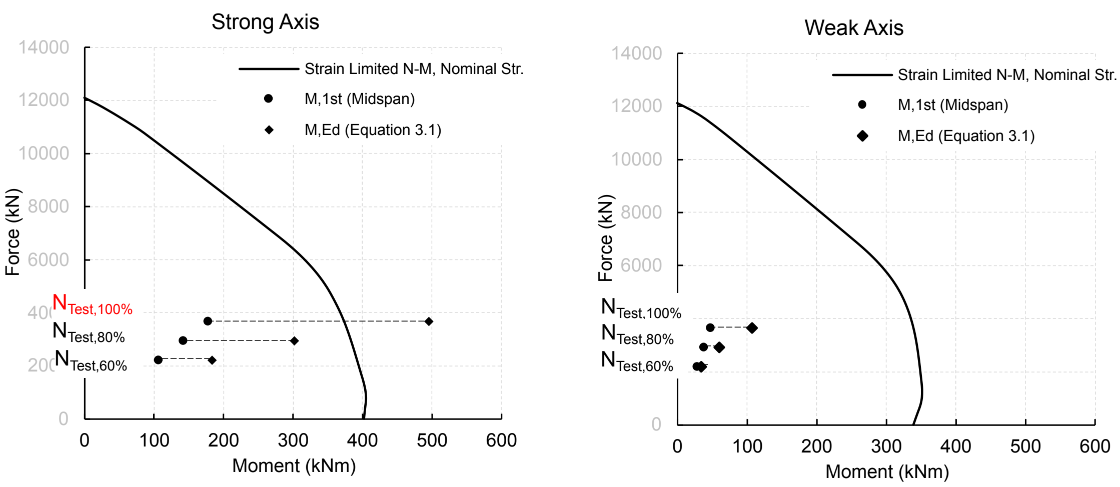


Figure 4.18. Interaction curve for A1.5 and 1^{st} order and 2^{nd} order moments

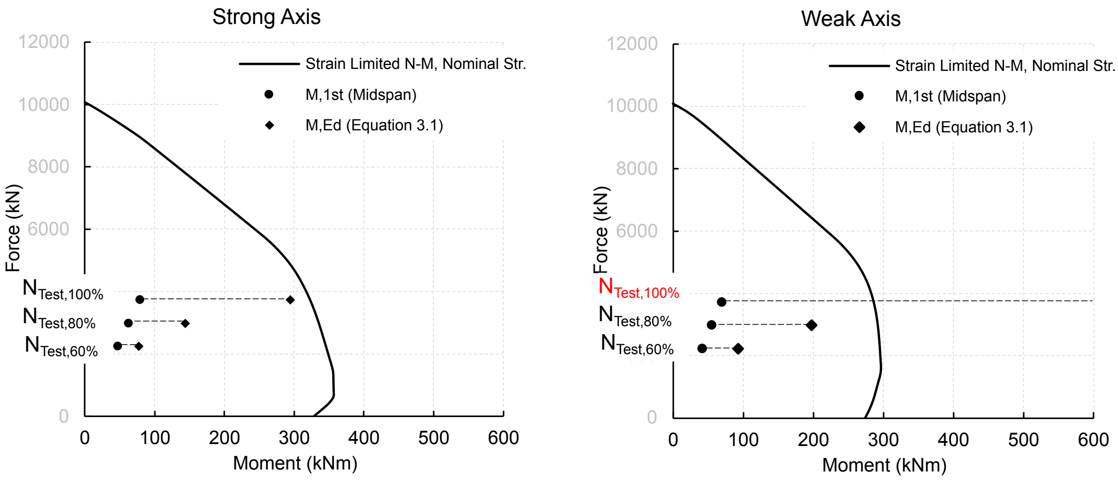


Figure 4.19. Interaction curve for B1.1 and 1^{st} order and 2^{nd} order moments

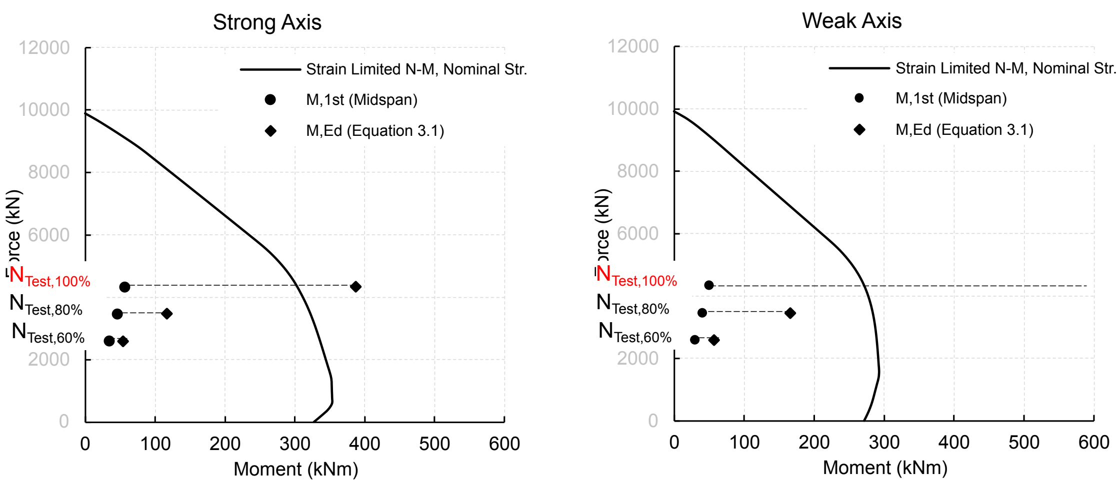


Figure 4.20. Interaction curve for B1.2 and 1^{st} order and 2^{nd} order moments

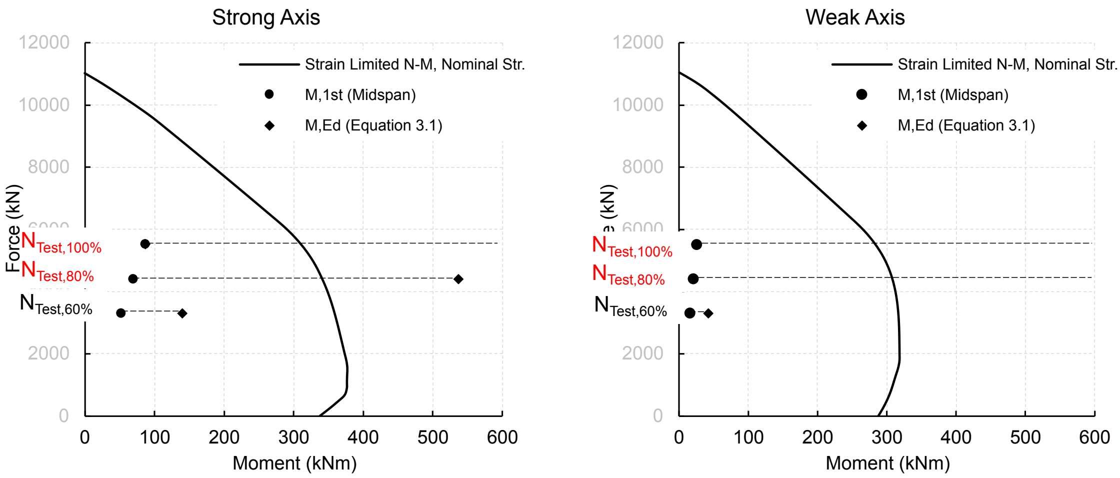


Figure 4.21. Interaction curve for B1.3 and 1^{st} order and 2^{nd} order moments

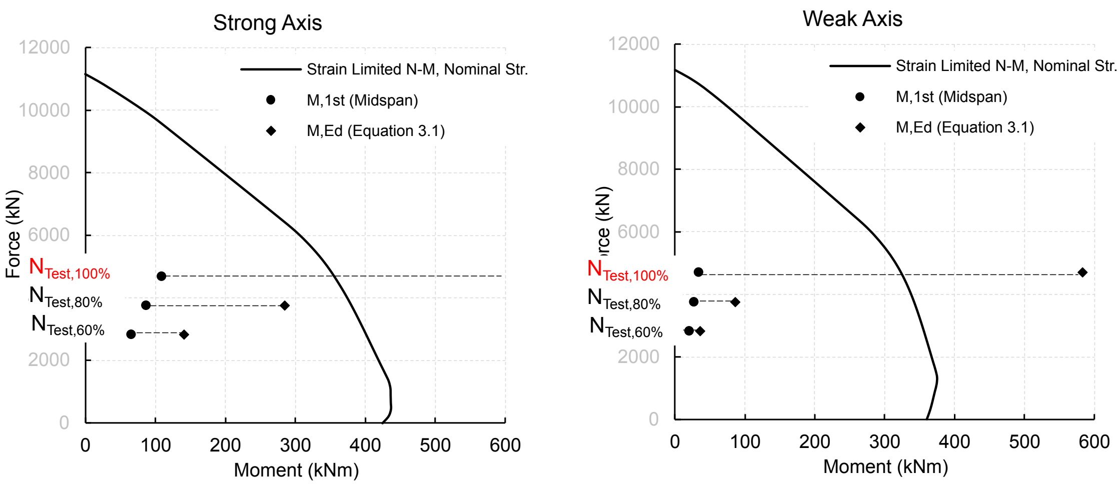


Figure 4.22. Interaction curve for B1.4 and 1^{st} order and 2^{nd} order moments

Figures 4.14 to 4.22 show the strain-limited interaction curves for all specimens with nominal material strengths. Round points show the first order internal bending moment at mid-span and diamond shaped points show the output of Equation 4.1 for each load level. They show better capture of failure in comparison to the 1st approach. All columns show failure in the planned axis of bending except of B1.1. All of the columns reach a minimum utilization of 80% except of B1.3 This is due to ultimate test load exceeding N_{cr} in calculation of moment amplification factor for B1.3. It can be concluded that initial imperfections obtained from calibration of test results via FEA give much better utilization in comparison to Approach 1, as long as the check is done for principal axes only. When it comes to biaxial bending, capacity to design ratios from Eurocode 4's biaxial bending check for approach 2 is given in Table 4.4.

Table 4.4. (Biaxial Cross Section Actual Bending Moment)/(Eurocode 4 Resistance for Biaxial Bending) for Approach 2

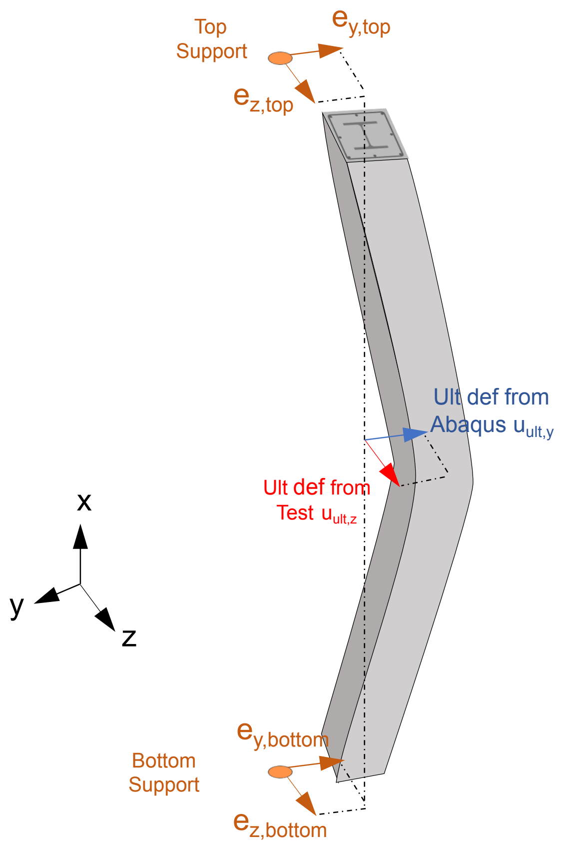
	Load Level (%)				
Specimen	20	40	60	80	100
A1.1	0.5	0.6	0.8	1.3	4.5
A1.2	0.6	0.7	0.9	1.3	2.2
A1.3	0.6	0.8	0.9	1.2	1.8
A1.4	0.7	0.8	0.9	1.2	1.8
A1.5	0.7	0.8	0.9	1.2	1.6
B1.1	0.5	0.7	0.9	1.4	3.1
B1.2	0.3	0.4	0.6	1.2	1.5
B1.3	0.1	0.2	0.5	1.6	-*
B1.4	0.4	0.5	0.8	1.2	3.9

$*$ Test load exceeded N_{cr} therefore internal moment can't be calculated

Table 4.4 shows that all of the specimens reach between 60% and 80% utilization when checked by biaxial bending control of Eurocode 4 using Approach 2. Results show better utilization than Approach 1. However, the ultimate capacity is still underestimated.

4.3. Biaxial Interaction Surface

The two approaches presented above focused on weak and strong axes separately and used Equation 4.1 to calculate maximum second order internal moment along the column. Although second approach showed better results, the way to combine biaxial bending still yields conservative results. To concentrate on this, a tool for creating biaxial bending interaction surfaces was created as explained in Section 7. This erases the need for an equation to combine biaxial bending and uses strain compatibility to obtain a failure surface for any combination of axial force and pairs of bending about principle axes. Since the used test specimens had measured load eccentricities in both directions, the failure load and second order bending moment will be shown on the interaction surface. Second order moments at the column midspan section were calculated using both test results and FEA results. Since the measurement of deflection during tests was only in one direction, the deflection at the other direction was taken from FEA. Then, second order midspan moment at the ultimate was calculated multiplying ultimate load with total deflection + eccentricity which include average load eccentricity in corresponding axis, deflection from test/FEA and initial bow imperfection from calibration. This is summarized in 4.23. Results in Figures 4.24 to 4.32 show the points of failure on the slices of interaction surface for ultimate force. All of the failure points lie outside or on the interaction surface and have a much larger distance to the Eurocode 4's linear combination as opposed to the biaxial failure surface. Circular specimens have a more significant difference due to their typology having large amount of concrete. This is a significant observation which proves superiority of circular encased sections under biaxial bending which cannot be utilized if Eurocode 4's linear combination is to be used.



$$M_{y,II} = N_{ult}\left[\frac{e_{z,top} + e_{z,bottom}}{2} + \frac{L}{w_0} + u_{ult,z}\right]$$

$$M_{z,II} = N_{ult}\left[\frac{e_{y,top} + e_{y,bottom}}{2} + \frac{L}{w_0} + u_{ult,y}\right]$$

Figure 4.23. Second Order Internal Moment Calculation

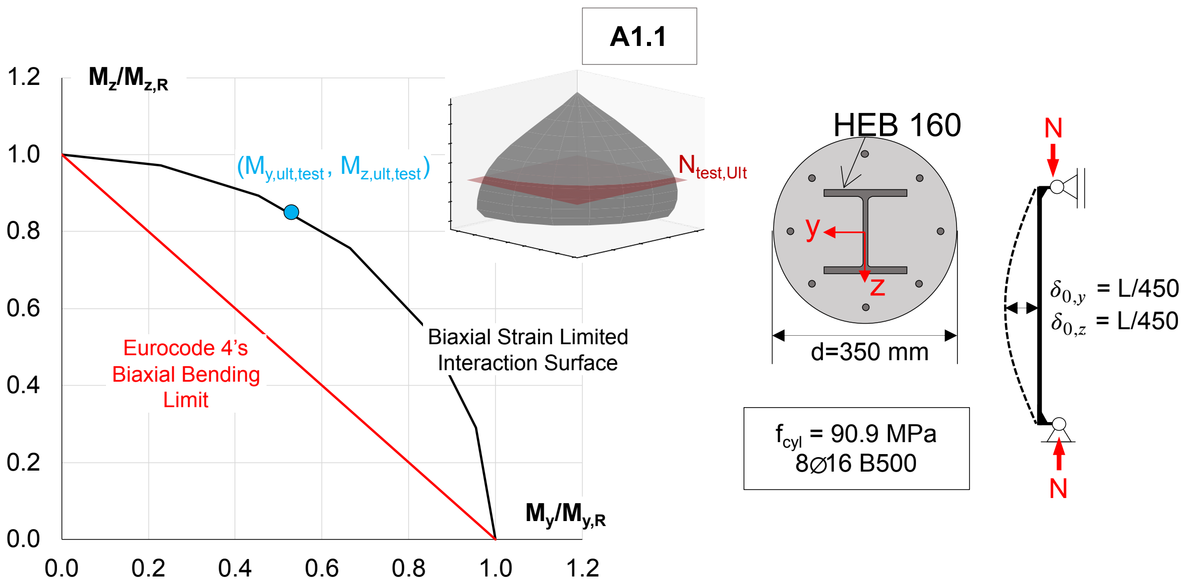


Figure 4.24. Biaxial Interaction Surface for A1.1

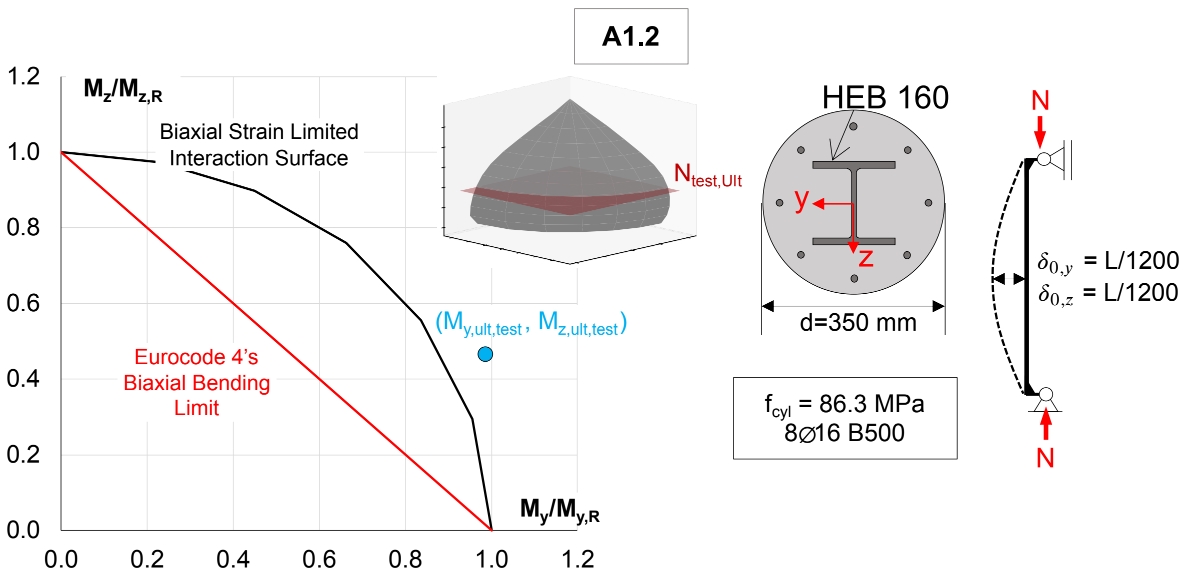


Figure 4.25. Biaxial Interaction Surface for A1.2

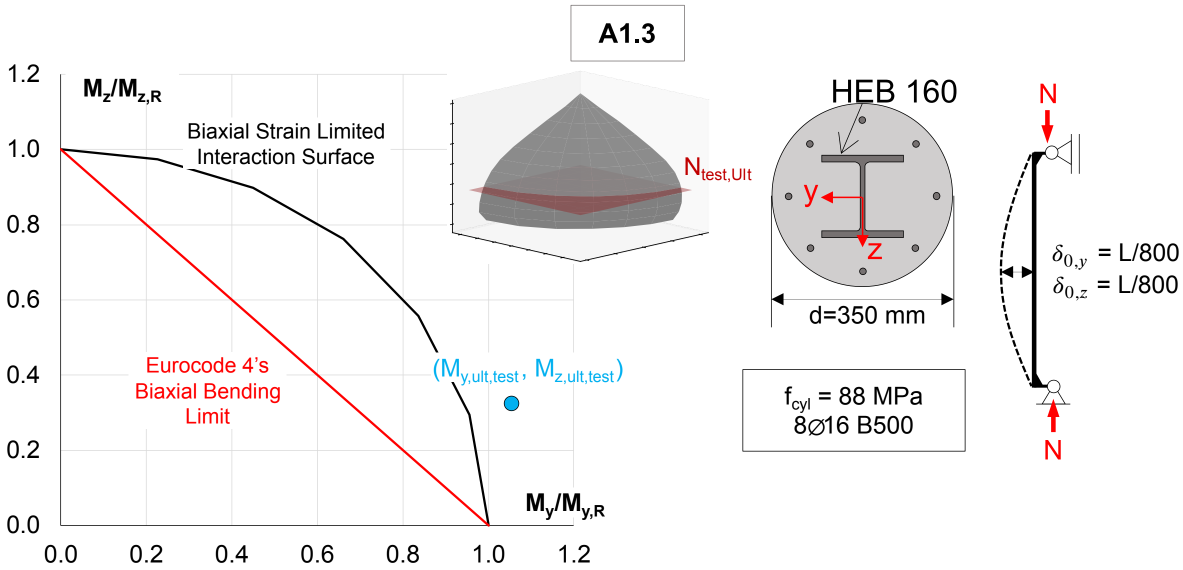


Figure 4.26. Biaxial Interaction Surface for A1.3

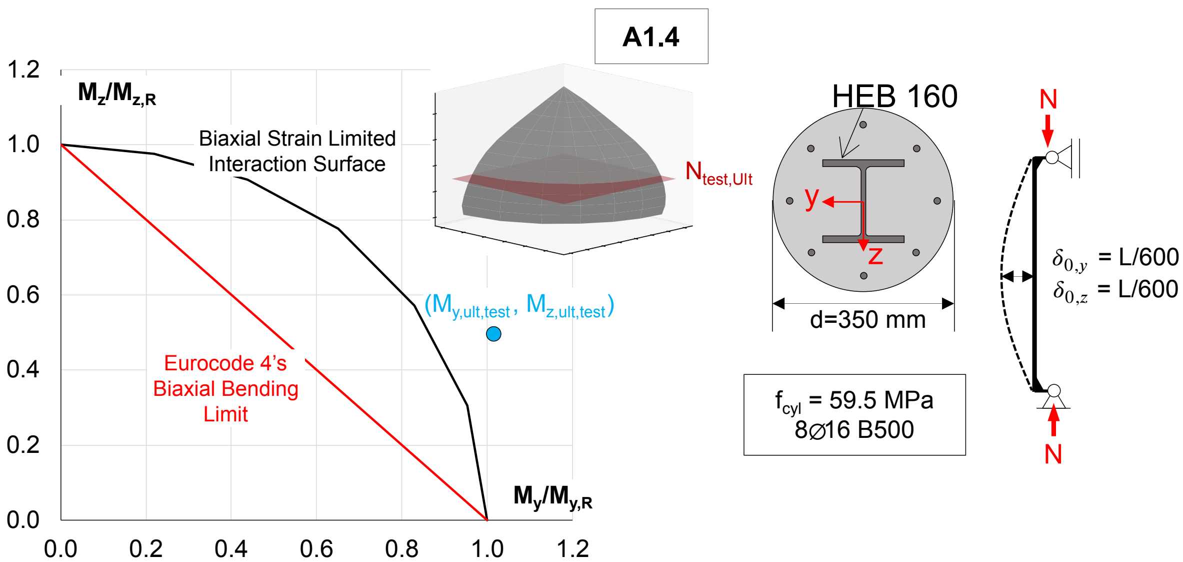


Figure 4.27. Biaxial Interaction Surface for A1.4

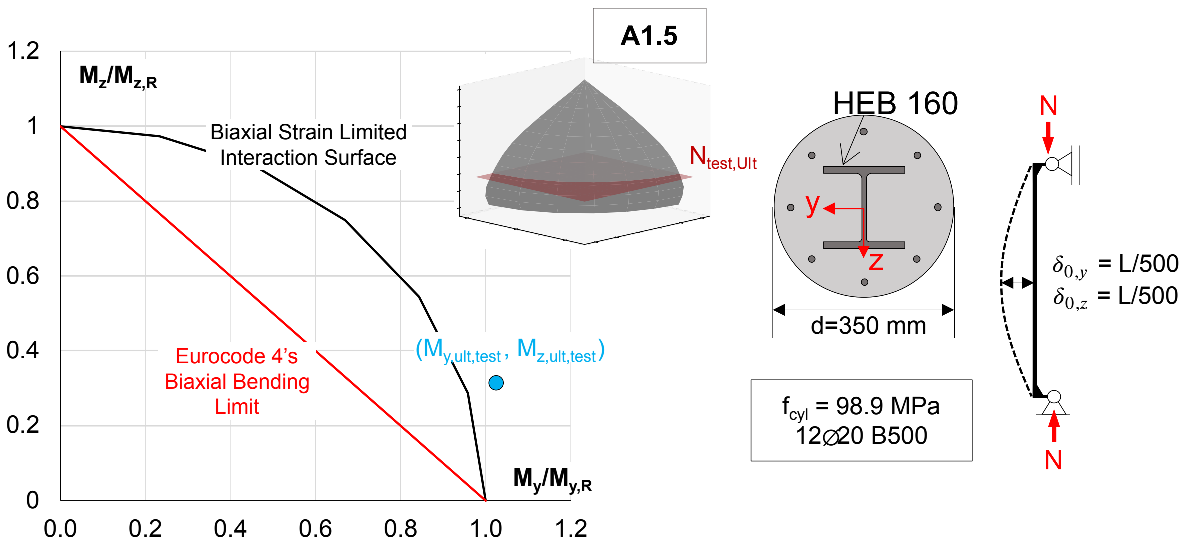


Figure 4.28. Biaxial Interaction Surface for A1.5

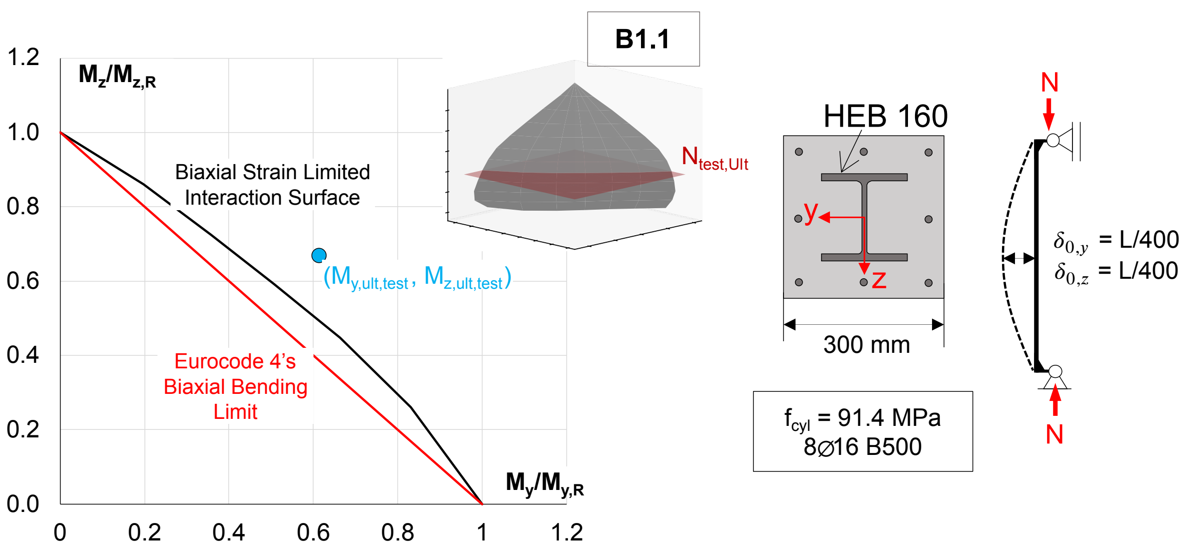


Figure 4.29. Biaxial Interaction Surface for B1.1

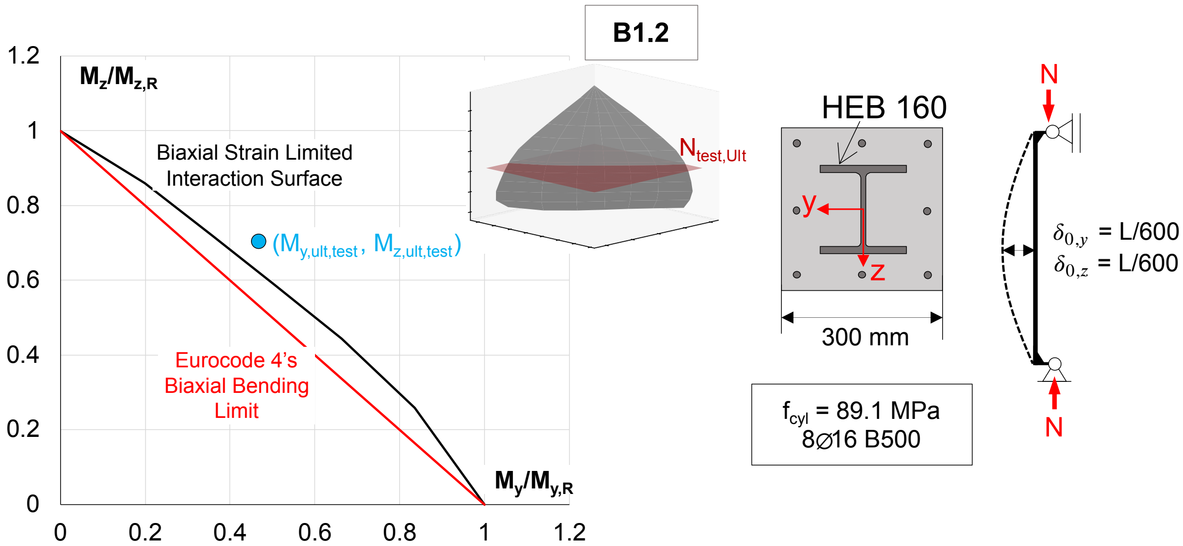


Figure 4.30. Biaxial Interaction Surface for B1.2

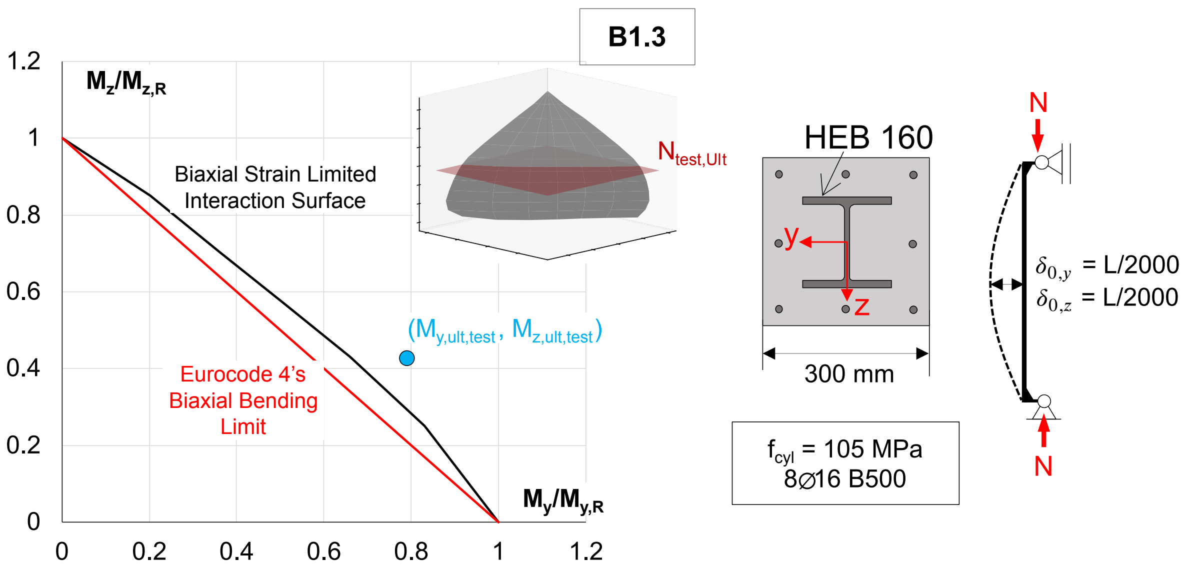


Figure 4.31. Biaxial Interaction Surface for B1.3

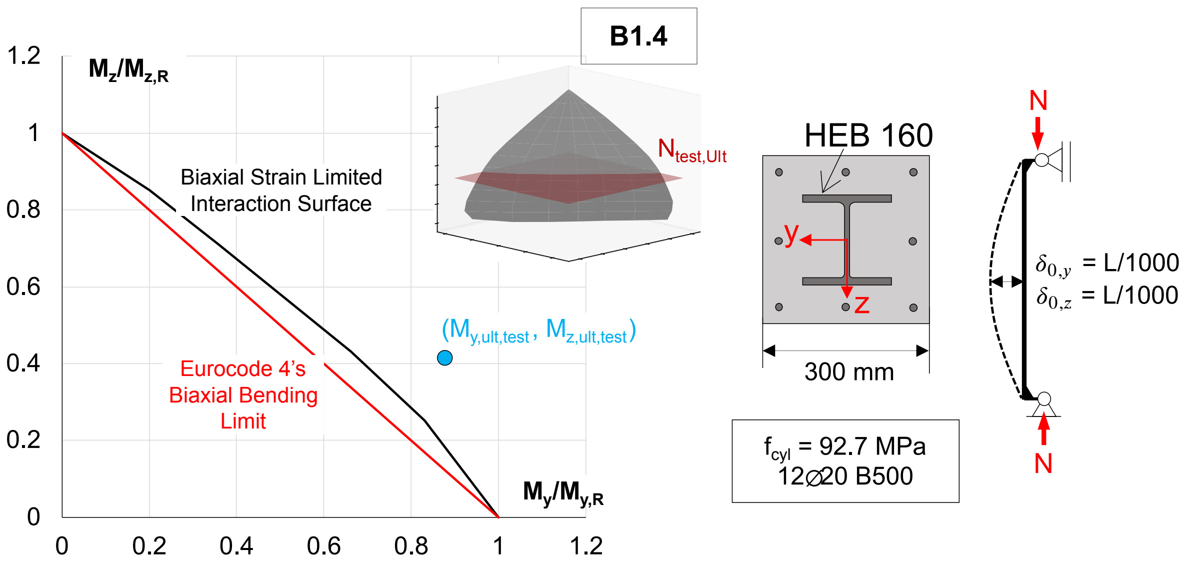


Figure 4.32. Biaxial Interaction Surface for B1.4

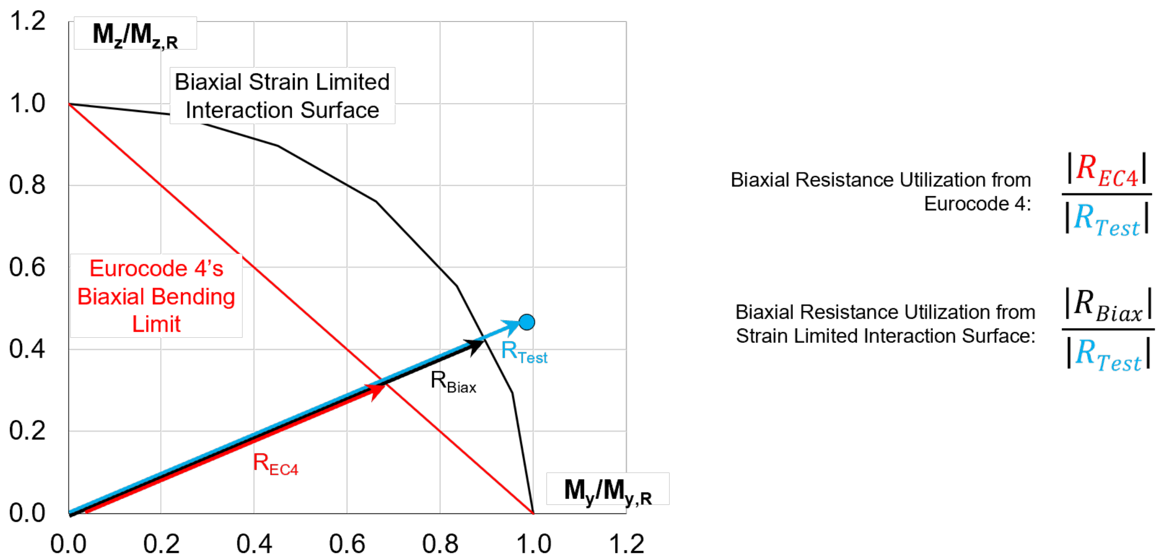


Figure 4.33. Calculating Utilization for Tests with Different Methods

Table 4.5. Resistance Utilization Comparison

Specimen	Linear Biaxial Interaction (Eurocode 4)	Biaxial Interaction Surface
A1.1 (Circular)	0.73	1.00
A1.2 (Circular)	0.69	0.95
A1.3 (Circular)	0.73	0.91
A1.4 (Circular)	0.66	0.92
A1.5 (Circular)	0.75	0.93
B1.1 (Square)	0.78	0.86
B1.2 (Square)	0.85	0.93
B1.3 (Square)	0.82	0.89
B1.4 (Square)	0.78	0.87

In this chapter, it was shown that the method of Eurocode 4 for capacity calculation of columns under combined bending and compression underestimated the capacities of test specimens. This is because the calculated moment amplification factor k results with high second order internal moment values. The main inputs to calculating k are initial bow imperfection and equivalent second order flexural rigidity $EI_{(eff,II)}$. To investigate the reason, a second approach was developed where initial bow imperfection was taken from the FEA calibration. The second approach improved the accuracy of the method significantly. However, imperfection values varied for each specimen and a uniform value was not set. Biaxial bending check was also done for both approaches and as expected, approach 2 gave better results although still underestimating the utilization. The reasoning behind was explained already in Figure 4.12. Findings in two approaches focused on only one of the inputs for calculating moment amplification factor, namely initial bow imperfection. The second input, $EI_{(eff,II)}$ has been neither calibrated nor validated. Upcoming parametric study of Chapter 6 will focus on this issue. A final approach was presented using a tool developed for plotting biaxial interaction surfaces as explained in Section 7. This allowed to show failure points with both bending components from two axes on a strain compatibility biaxial interaction surface. Results showed visually much better (less conservative) capture of failure especially for circular sections.

4.4. Background on $EI_{(eff,II)}$

The effective flexural stiffness to be used in calculation of second order internal moments has been developed in 1990s [16–20]. The development included fitting composite columns having certain geometry and material class combination to Eurocode

3's buckling curves by a geometrically and materially nonlinear finite element analysis conducted by beam elements and fiber sections [20]. In that analysis, geometrical bow imperfections were L/1000 and residual stresses were defined on steel as initial stress fields. Nonlinear material stress-strain curves were taken with design strengths and slenderness ratio vs the ratio of ultimate capacity to plastic section capacity was plotted on buckling curves to classify sections.

After classifying sections, several columns with different slenderness values on the chosen buckling curves were used to back-calculate equivalent bow imperfections to be used in simplified method of Eurocode 4 including second order effects. To do this, plastic interaction curve was taken as reference with varying slenderness, and for each slenderness, bow imperfection had to be such that the moment amplification reached exactly the limit of interaction curve at the same load that buckling curve gives as resistance. This was done by analytically calculating second order moments by assuming the imperfection shape to be a parabola and using equivalent flexural stiffness.

This procedure did not result with imperfection values that converge to a boundary for varying slenderness when the flexural stiffness was taken same as that used for calculating slenderness ratio. Therefore, it was modified to $EI_{(eff,II)}$ and different imperfection values were obtained for different slenderness that converge to an upper bound. This upper bound was then taken as reference to determine equivalent initial bow imperfection to use in second order analysis. The procedure detailed here is summarized also in Figure 4.34. This was done for all section types covered in simplified method of Eurocode 4.

4.5. Conclusion

The explained procedure in Figure 4.34 shows that initial bow imperfection for second order analysis and used equivalent flexural stiffness are coupled. However, they gave overconservative results for estimating test capacity as shown in Approach 1 in Section 4.2.1. The overconservative results can be attributed to several factors listed below.

- Nonlinear FE analysis to classify the sections used design resistance as the ultimate resistance of stress-strain curves. Keeping the constitutive equation shape

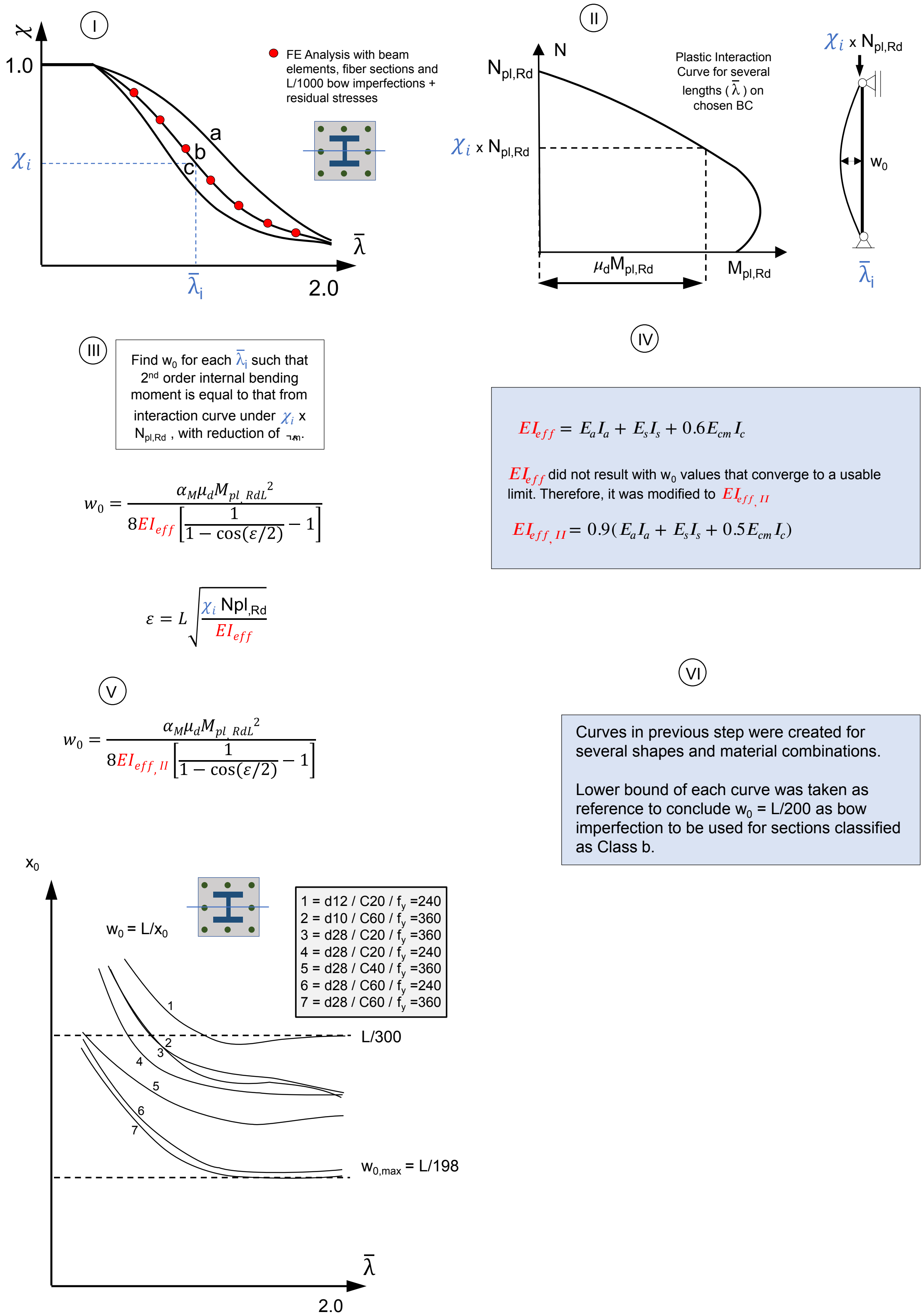


Figure 4.34. Procedure to Determine Initial Bow Imperfections for Current Simplified Method by Bergmann and Lindner [16–20]

but only reducing the ultimate resistance causes loss of stiffness. Instead, using mean material curves and than applying a safety factor could have resulted with different section classifications. Current general method of Eurocode 4 applies this approach in which the overall safety factor is determined by help of both design and mean interaction curves.

- Above procedure was done for sections with significant steel contribution. However, for the test specimens, failure is mainly governed by concrete.
- Moment capacity from plastic interaction curve was reduced with α_M to account for strain limitation of concrete in comparison to steel. There exists already a safety factor from determination α_M. Using this for the moment capacity of the section at failure starts with a conservative assumption. Strain-limited moment capacity could have been used instead of plastic moment capacity reduced by α_M.
- Determined initial bow imperfection was dependent on slenderness but a threshold value had to be chosen to be used in design, this amplifies already existent safety factor from α_M. In addition, the upper bound of imperfections converged to a limit around high slenderness, for lower slenderness, the calculated imperfections were much smaller than the threshold value. This causes common height (non-slender) columns to be non-economical because they have to be designed with imperfections determined for slender columns.

Findings in this Chapter lead to the investigation on equivalent imperfections and second order flexural stiffness as well as design for biaxial bending. Therefore, in the following parts of this dissertation, focus is set on those phenomena. The next chapter investigates imperfections, Chapter 6 presents extensive parametric study with conclusions about flexural stiffness and Chapter 7 presents a novel method for biaxial bending check.

5. IMPERFECTIONS

In design of columns, geometrical and physical imperfections are considered in the capacity and action effect calculations. This is to cover possible out of straightness, errors in execution, unplanned load eccentricity, residual stresses in steel. Different European construction norms consider the imperfections with varying approaches. This was studied by the author [47], where geometrical imperfections definitions and requirements of different building and execution standards were compared. There are major differences in magnitude of geometrical imperfection to be considered for steel and reinforced concrete structures. Since composite sections have both of these materials, it is difficult to adapt a single approach of them.

5.1. Geometrical imperfections

Eurocode 2 requires the designer to assume a load eccentricity even when the column is designed for only normal load. Distinction is made between structural analysis and capacity calculation for ultimate limit state. For the former, a load eccentricity with L/400 must be considered with L being the column length. For the capacity under ultimate limit state, greater of 1/30th of the section depth or 20 mm must be taken as load eccentricity. Residual stresses are not mentioned since no steel profile is present in the scope.

EN 13670 [48] gives the construction tolerances for reinforced concrete buildings. Two cases for columns are defined. One is the offset between the column central axes of neighboring floors. This shall not be greater than 1/30th of the overlying column average depth or 30 mm. This case represents a load eccentricity. Second case is out of straightness or bow imperfection of the column. This shall not be greater than L/300, L being the column length, if L/300 falls between 15 and 30 mm. 15 and 30 mm are the limits for the smallest and largest tolerance.

Eurocode 4 considers geometrical imperfections for columns for general method of design and simplified method of design. For general method of design, the size of initial bow imperfection is not specified but it is required to be considered together with residual stresses to be included in the nonlinear high fidelity finite element analysis. L/1000 is commonly found in literature to be the typical size of bow imperfection used in nonlinear FE analysis for steel hence composite columns. Background on this value is given in [14]. For the simplified method of design, a table with different section types with corresponding equivalent initial bow imperfection values is presented. Equivalent imperfection values range from L/300 to L/150. These values are high compared to other approaches. The reason lies in how the values were determined. In Section 4.4 it is explained that the imperfections are determined such that they give the same resistance with the buckling curve they are classified in under normal loading. In addition, these values represent not only geometrical imperfection but also residual stresses on the steel sections.

An extensive study about the measurement of geometrical imperfections of composite columns does not exist. In the found literature, the common approach is to adopt L/1000 as the bow imperfections for composite columns in finite element analysis. Building codes give more conservative imperfection values to account for other unknown sources of imperfections. The show the reduction in calculated capacity with different bow imperfection values, a comparison was made using FE analysis on columns given in Figures 5.1 and 5.2. Different values of bow imperfections, L/1000, L/600 and L/400 are compared for 3 and 6 meter long columns. Drop in resistance is higher for longer columns due to amplified internal bending moments. Drop of resistance from L/1000 to L/400 is shown to be as high as 13%.

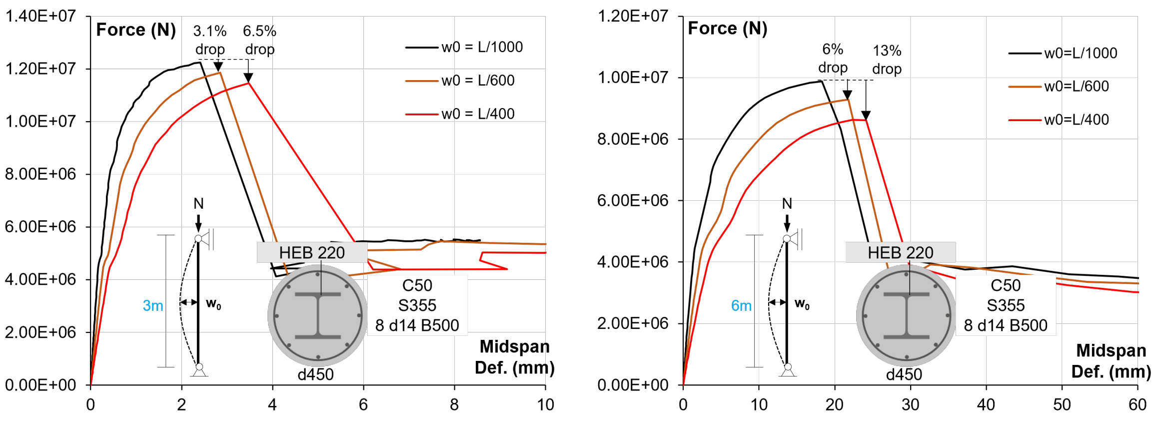


Figure 5.1. Effect of Bow Imperfections on Resistance of Circular Encased Columns

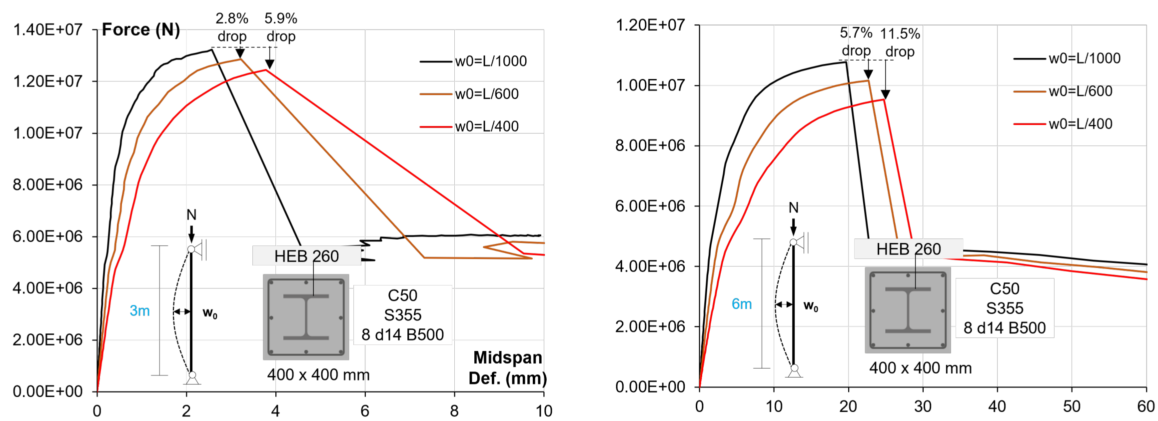


Figure 5.2. Effect of Bow Imperfections on Resistance of Square Encased Columns

5.2. Residual Stresses

Residual stresses are the stress field present in steel with absence of loading. They stem from the production processes. EN 1993-1-14 regulates the stress field distribution to be considered when modelling nonlinear finite element analysis. Residual stresses are significant for the design of steel members. They not only take up some capacity before loading, but they also make members more susceptible to local buckling. Concrete encased steel sections which are the subject of this dissertation on the other hand, already restrain the local buckling of internal steel with the existence of concrete. In other words, residual stresses on steel are not as detrimental for this typology as they are for pure steel members. This is represented on an example column modelled with FE modelling approach given in Chapter 3 with and without residual stresses.

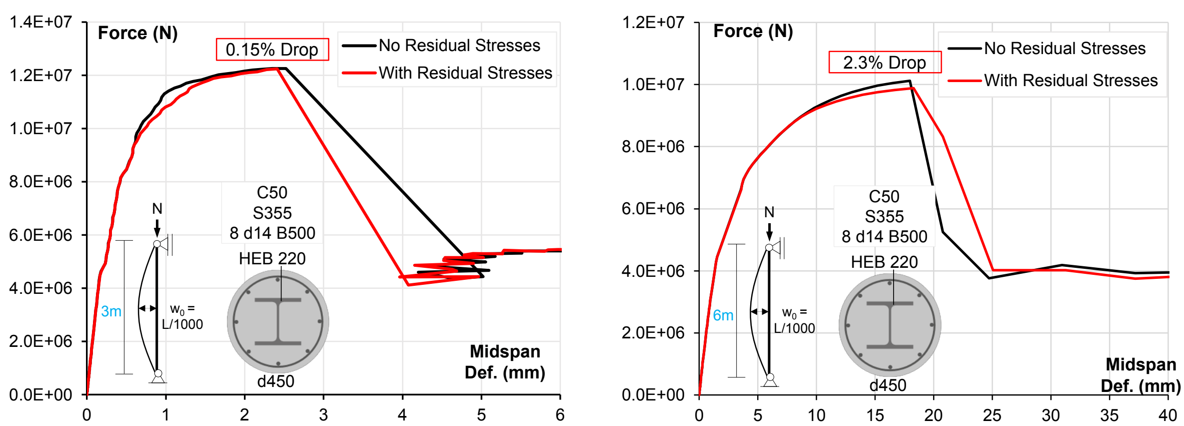


Figure 5.3. Effect of Residual Stress Modelling on Resistance of Circular Encased Columns

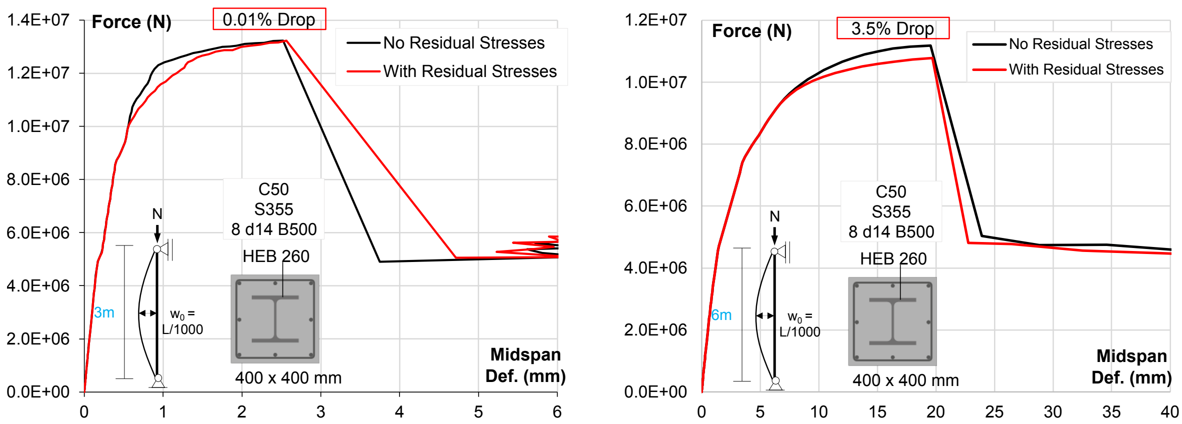


Figure 5.4. Effect of Residual Stress Modelling on Resistance of Square Encased Columns

Figures 5.3 and 5.4 show two column types with circular and square concrete encased steel sections each modelled once with residual stresses and once without. For 3 m columns, load deflection curves show almost no reduction in strength, only loss of stiffness at high load level. This finding is significant since the Eurocode 4's imperfections for concrete encased steel sections are quite high. They represent not only geometrical imperfections but physical imperfections which cover residual stresses. Presented comparison proves the effect of residual stresses are low and equivalent imperfections for concrete encased steel sections might be overconservative. For 6m long columns, the effect of residual stresses get more significant. For the square section, loss of strength reaches 3.5%. This is due to larger deformation at failure for longer columns. Looking at the horizontal axis, deflections are much higher for 6m columns than 3m columns. This in turn increases the bending at midspan axis and initial stress field on the steel. It must be noted however, 3m columns are much more common to be found in engineering practice than 6m columns since usually that would be the height of a story. And for this height, residual stresses play very little role for concrete encased sections.

5.3. Imperfections due to Production

Another source of imperfections can be counted as the ones stemming from production processes. Concrete encased steel columns have a production process different than pure steel or reinforced concrete columns. The steel profile has to be surrounded by the reinforcement first, than the concreting has to be done. The imperfections from the steel, reinforcement, their placement will be superposed during the procedure which might be unfavorable. In addition, the formwork has to be brought around and concreting will take place either vertically or horizontally. Latter might further cause out of straightness of the column. The unique construction process of the encased columns makes them more susceptible to imperfections than steel or RC columns. Possible non-alignment of reinforcement and steel profile with the design was investigated by the author in a previous publication [47]. It was shown with different scenarios that for composite columns, a value between that of steel structures and composite columns for the imperfection magnitude would be reasonable. This also supports the use of L/600 found in Chapter 3 for the average imperfections. However, since the end eccentricities were explicitly measured and reported in [1], L/600 does not include unplanned load eccentricities, it includes possible placement error or the rebar and profile and out of straightness of the formwork and thus column.

5.4. Conclusion

In this chapter, imperfection definitions on concrete encased columns were further investigated. The values given by Eurocode 4's simplified method of design for these columns are L/200 and L/150. These imperfection values are quite high, and the reasoning behind high imperfections is the effects due to residual stresses on steel as well as geometrical imperfections. In this chapter, it is shown that residual stresses do not have a significant effect on resistances of encased sections with flange thicknesses less than 40 mm. This is due to the concrete covering whole steel section, hence lack of local buckling risk and failure being governed by concrete crushing. It is questionable if concrete encased sections in fact need higher initial bow imperfection definitions than reinforced concrete columns.

Different geometrical imperfections on the other hand are also compared in this chapter and shown to have a more significant impact on resistance. Not to forget, overall outer dimensions of the column will follow the formwork, just as a reinforced column would do. More sophisticated imperfection scenarios were compared in [47] considering out of placement of internal profile with respect to overall bow imperfection but the values of current Eurocode are not to be reached even with those sophisticated scenarios.

With light of obtained results, a lower imperfection value for concrete encased steel columns might be plausible. This will be investigated in the next chapter.

6. PARAMETRIC STUDY & NOVEL STRAIN LIMITED DESIGN METHOD

Analysis of the column test results showed previously that the columns failed in biaxial bending. The biaxial bending interaction equation of Eurocode 4 is highly conservative and if one wants to create a surface for biaxial bending interaction equation it is cumbersome. Instead, with the already calibrated finite element model, a parametric study for concrete encased steel columns of square and circular sections is prepared. In the parametric study, boundary conditions are such that bending is only about predefined weak or strong axis. Initial bow imperfection is also only defined for the relevant axis of bending. The magnitude of initial bow imperfection is an important factor in the behaviour of slender columns. The calibration of test specimens resulted with an average bow imperfection of L/660. This is used as a basis in parametric study and initial bow imperfection is fixed slightly more conservatively as L/600.

Table 6.1. Parametric Study Inputs

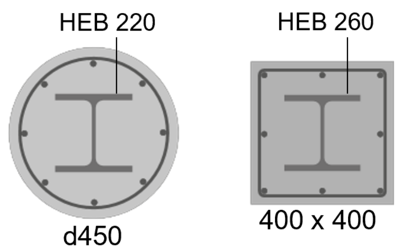
Section & Profile	
Concrete Strength	C30, C50, C60, C90
Profile Strength	S355, S460, S550
Reinf. Amount	8ϕ14 B500, 8ϕ25 B700
Column Length (m)	3, 4, 6, 8, 10
e/D (Load ecc. to Column Dimension)	0, 0.1, 0.2
Bending Axis	Strong, Weak

Table 6 shows the input parameters for the study. Two sections, namely circular with diameter of 450 mm with HEB220 steel profile and square with dimensions 400 mm by 400 mm with profile HEB260 were chosen. For the choice of sections, Eurocode 4's spacing requirements between profile and concrete face for square section was considered. Also the steel contribution ratio and reinforcement ratio requirements were hold. There is no specification for circular sections in the code. Therefore, attention was given for the spacing between flange ends end column surface which is the shortest distance between two elements. Enough space was provided for reinforcement and concrete cover. C30/37, C50/60, C60/75 and C90/105 concrete are used to cover normal and high strength concrete. S355, 460 and S550 steel was chosen to utilize steel strength. Two reinforcement settings 8 d14, B500 and 8 d25, B700 longitudinal rebars were used. Mean material resistances f_{cm}, f_{ym} and f_{sm} for concrete, structural steel and reinforcing steel were used respectively with below given values. Stress-strain curves for all materials are given in Figures 2.6, 2.7 and 2.8.

$f_{cm} = f_{ck} + 8$ in acc. with. Eurocode 2 [24]

$$f_{ym} = \begin{cases} 1.25 f_{yk} & \text{for S235 and S275} \\ 1.20 f_{yk} & \text{for S355 and S420} \\ 1.15 f_{yk} & \text{for S460} \\ 1.10 f_{yk} & \text{for above S460} \end{cases} \quad \text{in acc. with Table E.1 of Eurocode 3 [4]}$$

$f_{sm} = 1.0768 f_{sk}$ in acc. with Table A.1 of Eurocode 2 [24]

Four different lengths of 3,4,6,8 and 10 were chosen. To account for different bending settings, three different load eccentricity levels from none to 0.1 and 0.2 were defined. And finally, direction of load eccentricities and initial bow imperfections were arranged for both weak and strong axes for each resulting input. A combination of $2 \times 4 \times 3 \times 2 \times 5 \times 3 \times 2 = 1440$ cases were obtained and all of them were simulated in Abaqus.

6.1. Classification of Sections to European Buckling Curves

The European buckling curves are used for design of centrically loaded composite columns in accordance with the simplified method of Eurocode 4. For simplified method to be applicable to a composite column, it has to have a relative slenderness less than 2, concrete, structural steel, reinforcing steel strength and reinforcement ratio shall not exceed C50/60, S460, B500 and 6% respectively and the section type has to be one of those given in Table 6.5 of Eurocode 4. Table 6.5 includes rectangular concrete encased steel columns but excludes circular concrete encased steel columns which are part of this dissertation. The parametric study extends the requirements of simplified method by covering high strength concrete, steel and reinforcement as well as circular encased sections. This allows for classification of sections and material combinations that fall outside of the scope of simplified method. In this section, classification of the columns from parametric study is explained.

Abaqus runs of the columns of parametric study utilized mean strengths of the corresponding strength class. This was to inhibit the likely loss of stiffness and therefore strength if design strengths were used. To reach from mean resistance of the column to its design resistance, overall safety factor as defined by Eurocode 4's general method for design of composite columns was calculated for each run. To calculate the overall safety factor, mean and design interaction curves were created for each section, a point with coordinates of ultimate internal bending moment and ultimate load was placed on the curve, mean and design vectors were drawn starting from origin, intersecting with the point and reaching mean and design interaction curves, respectively. Then, the ratio of the lengths of mean to design vector is determined as the overall safety factor for the corresponding parametric study run, finally, design resistance is determined by dividing ultimate force from Abaqus run by overall safety factor.

The interaction curves were drawn using strain compatibility instead of plastic section resistances. The material constitutive relationships were taken same as those from FE parametric study.

After obtaining the design resistance of a parametric study run, its ratio to plastic section resistance was obtained and that ratio is plotted against relative slenderness on the buckling curves for purposes of classification. The procedure is summarized in Figure 6.1

For the cases with creep, the slenderness ratio was calculated with creeped flexural stiffness, for others without.

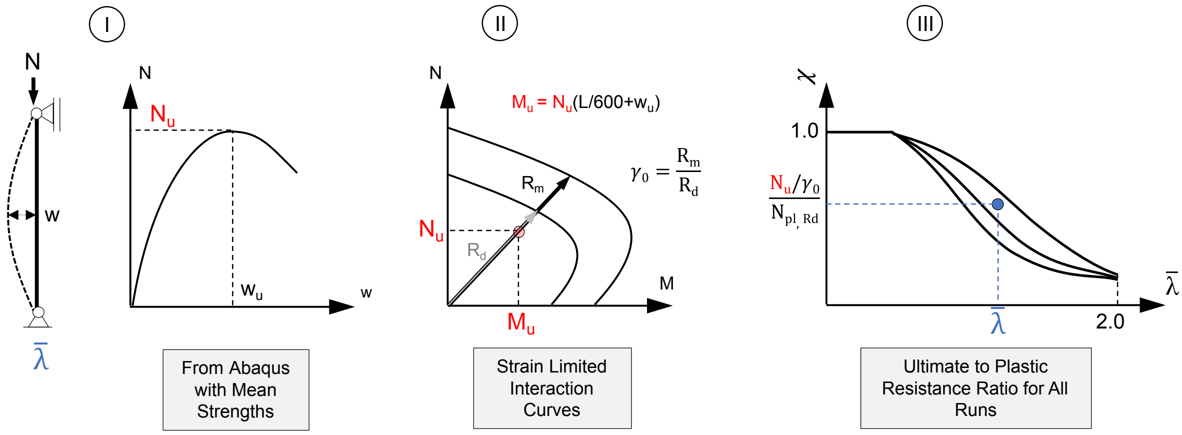


Figure 6.1. Classification of Columns from Parametric Study

Calculation of slenderness ratio to be used in buckling curves requires considering creep effects on concrete. The tests used to calibrate the FE modelling were short term tests and therefore did not contain creep effects. Classification of sections without creep effects can be misleading since ultimately, a designer has to use that. To overcome this issue, all of the specimens without load eccentricity were run twice, with and without creep. Including creep effects for FE analysis is not typical and literature does not have many resources outlining how to apply. In this study, creep effects were included in the FE analysis by modifying the stress-strain relationship and modulus of elasticity of concrete in accordance with Eurocode, see Figure 6.2. the stress strain curve was shifted to the right by multiplying strains with one plus creep coefficient. According to the Eurocode 4's requirements for creep, initial modulus of elasticity was reduced by dividing it by one plus creep coefficient times permanent to total load ratio. Since in the parametric study there is no permanent and variable load difference, this ratio was assumed to be constant and 0.7. This is presented in Figure 6.2. Creep coefficient was calculated based on indoor conditions of Eurocode 2. It depends on section geometry and concrete class. Higher concrete class results with a relatively lower creep coefficient than that from lower concrete classes.

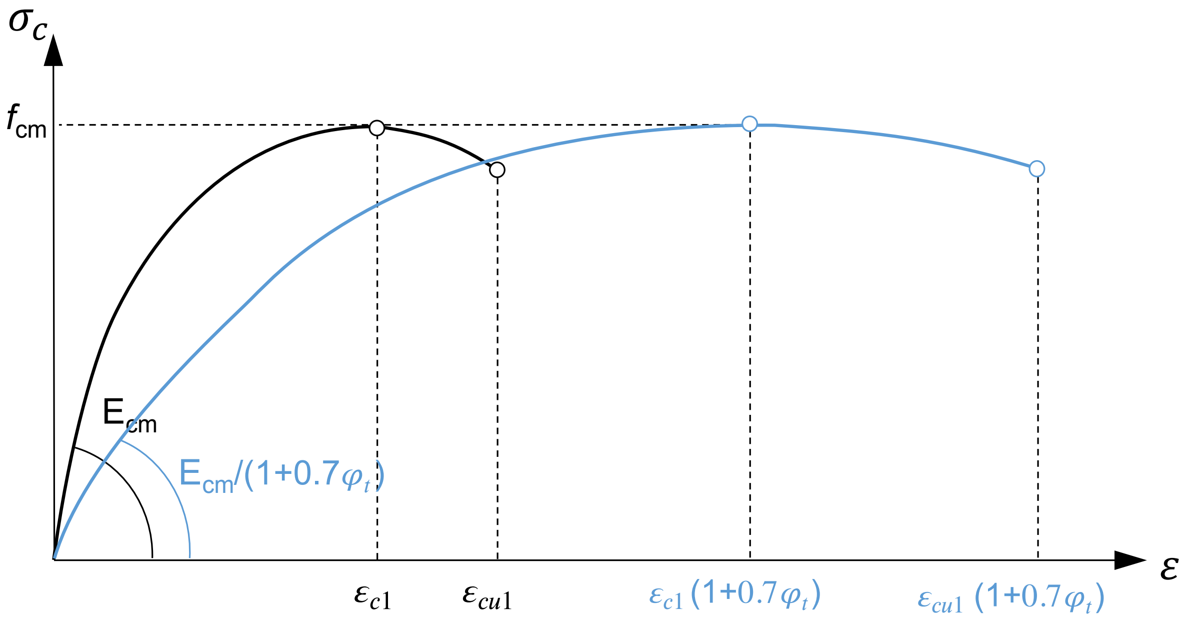


Figure 6.2. Concrete Stress Strain Curves with and without Creep

The effect of creep on slenderness ratio $\overline{\lambda}$ is shown in Equation 6.1. Creep reduces the modulus of elasticity of concrete and therefore increases the slenderness value. Effect of creep to the χ value on the other hand is not straightforward to see. Generally, for non-slender columns, creep increases it and for slender columns has the opposite effect.

$$\overline{\lambda} = \sqrt{\frac{N_{pl,Rk}}{N_{cr}}} \tag{6.1}$$

$$N_{pl,Rk} = A_a f_{yk} + A_c f_{ck} + A_s f_{sk} \tag{6.2}$$

where, N_{cr} = Elastic critical buckling load calculated using EI_{eff}

$$EI_{eff} = E_a I_a + E_s I_s + 0.6 E_{c,eff} I_c \tag{6.3}$$

$$E_{c,eff} = \frac{E_{cm}}{1 + (N_{G,Ed}/N_{Ed})\,\varphi_t} \tag{6.4}$$

where, φ_t is the creep coefficient from Eurocode 2.

N_{Ed} is the total design normal force

$N_{G,Ed}$ is the permanent design normal force

Procedure in Figure 6.1 was applied for every parametric run without eccentricity with and without creep. This resulted in a sum of 768 samples. In Figures 6.3 and 6.4, all of the points are shown. Scatter is obvious and therefore the points were broken down for different section shapes, concrete strength, structural steel strength and bending axis. On the x axis, slenderness value correlates with length of the samples. Scatter plots were created for each possible combination and then classification was performed as shown in Figures 6.5 to 6.12. In the figure legends, samples with creep are shown as blue points and structural steel class is represented by the sizes of the points, increasing size implies higher structural steel grade.

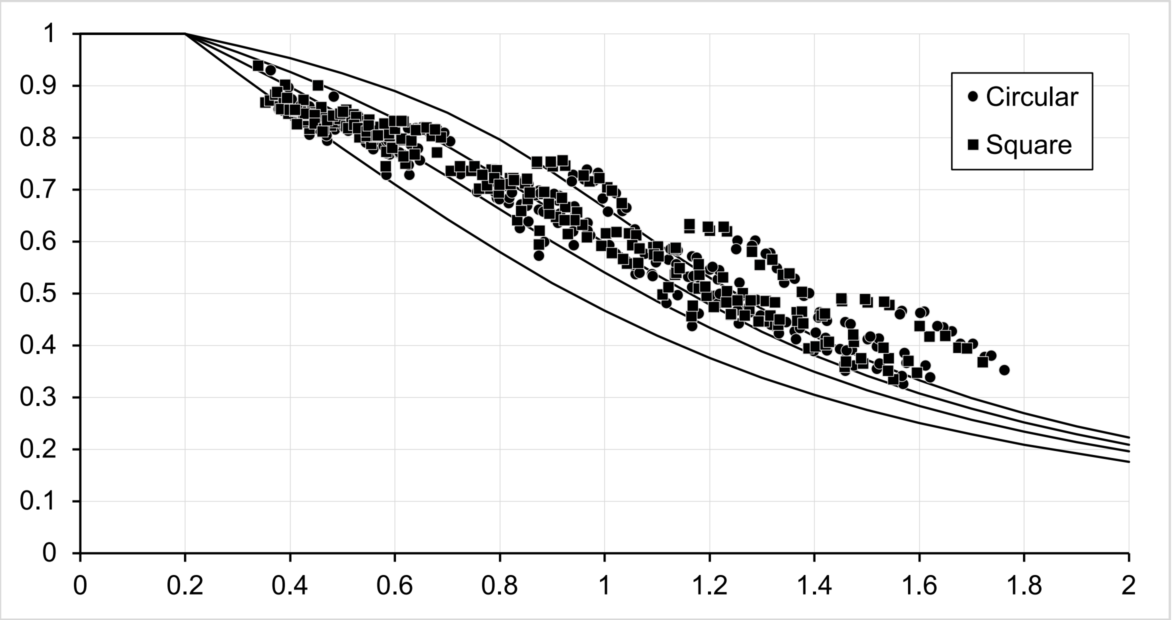


Figure 6.3. Centric Loaded Runs without Creep On Buckling Curves

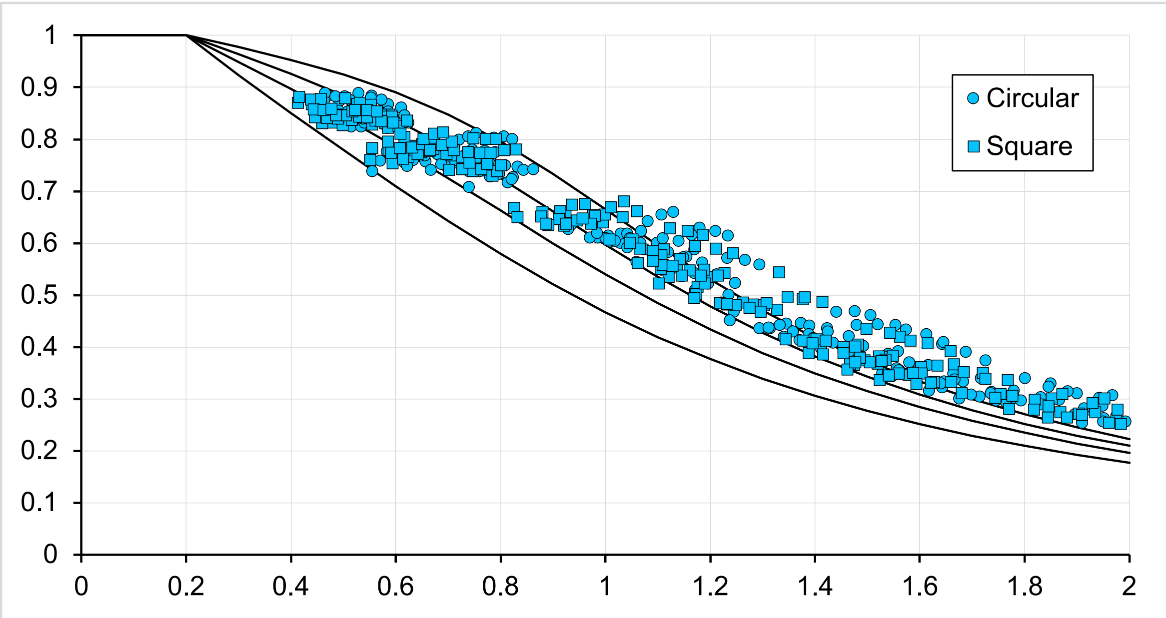


Figure 6.4. Centric Loaded Runs with Creep On Buckling Curves

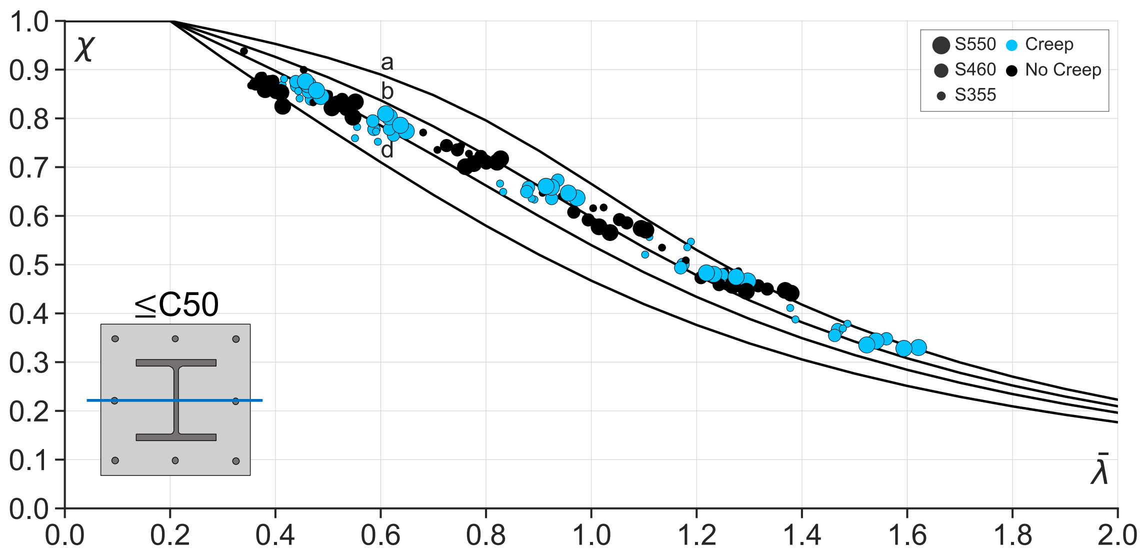


Figure 6.5. Centric Loaded Square Sections with Normal Strength Concrete Bending about Strong Axis.

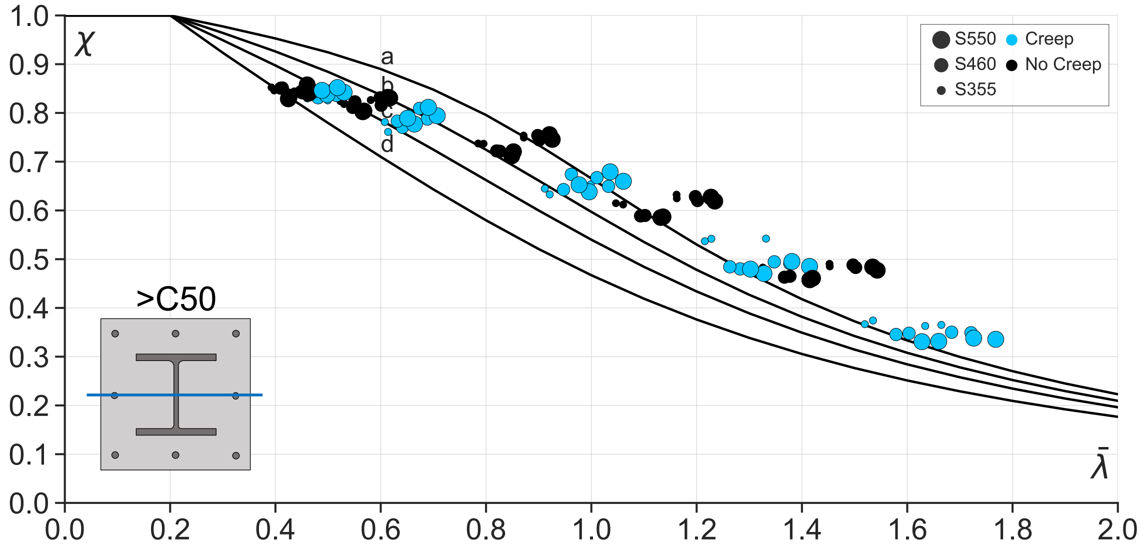


Figure 6.6. Centric Loaded Square Sections with High Strength Concrete Bending about Strong Axis.

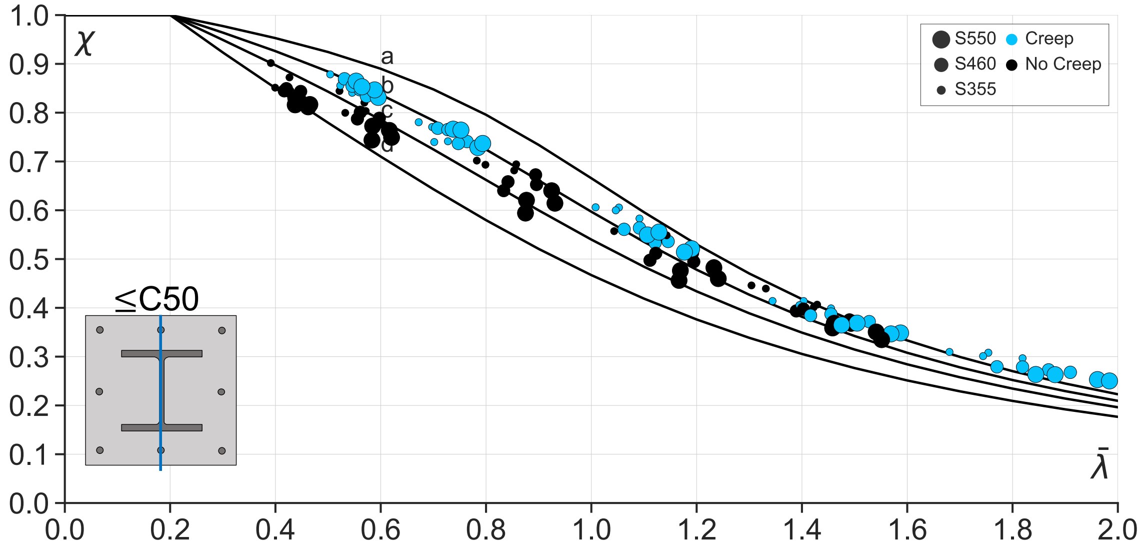


Figure 6.7. Centric Loaded Square Sections with Normal Strength Concrete Bending about Weak Axis.

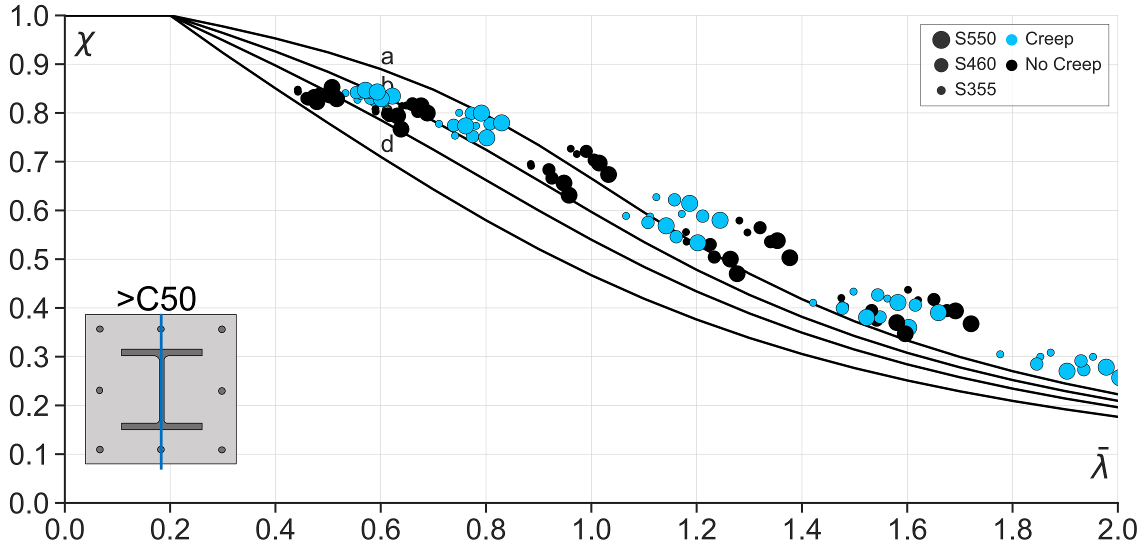


Figure 6.8. Centric Loaded Square Sections with High Strength Concrete Bending about Weak Axis.

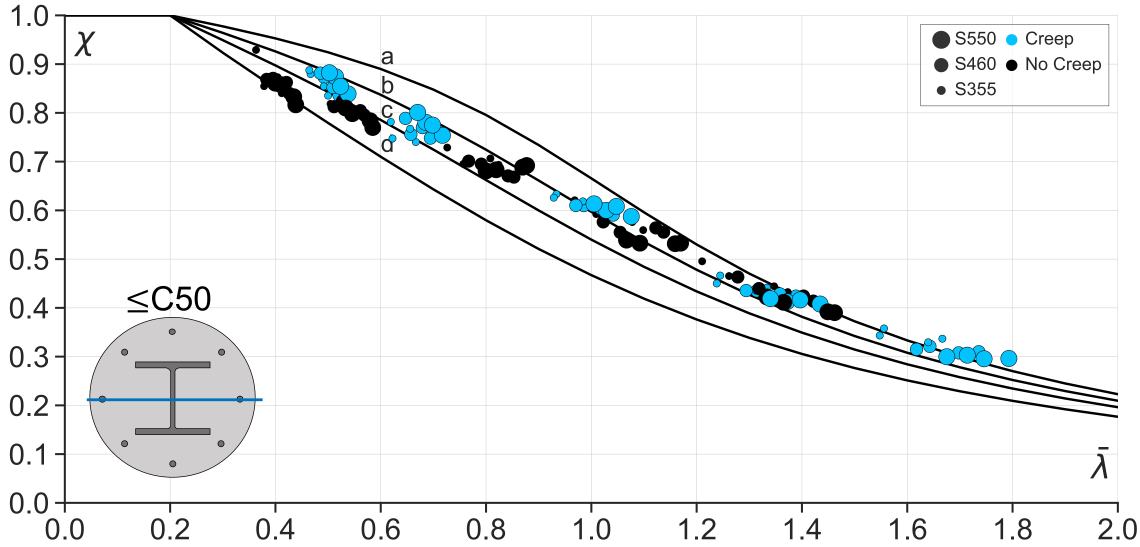


Figure 6.9. Centric Loaded Circular Sections with Normal Strength Concrete Bending about Strong Axis.

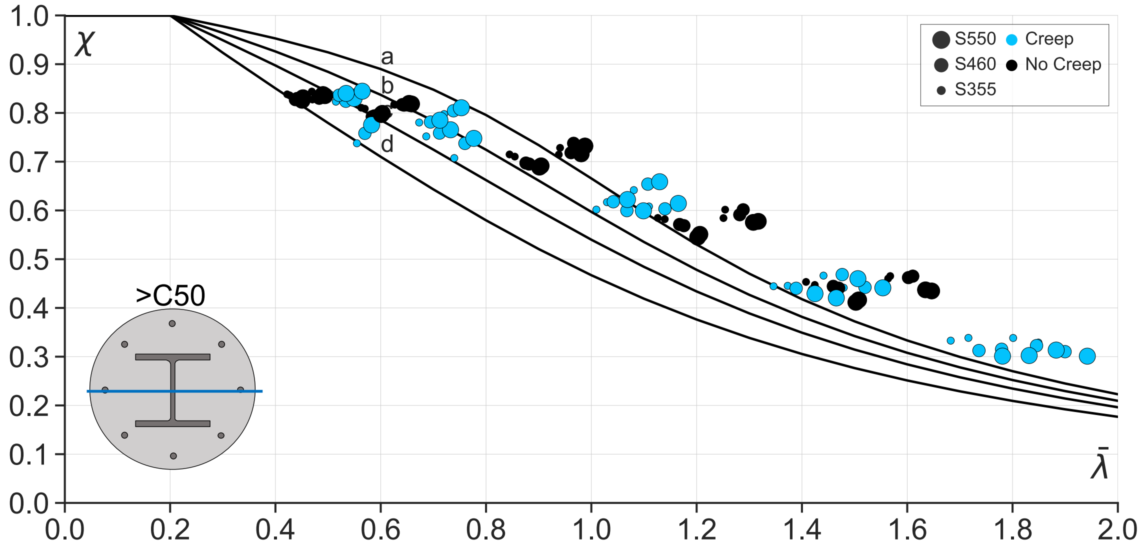


Figure 6.10. Centric Loaded Circular Sections with High Strength Concrete Bending about Strong Axis.

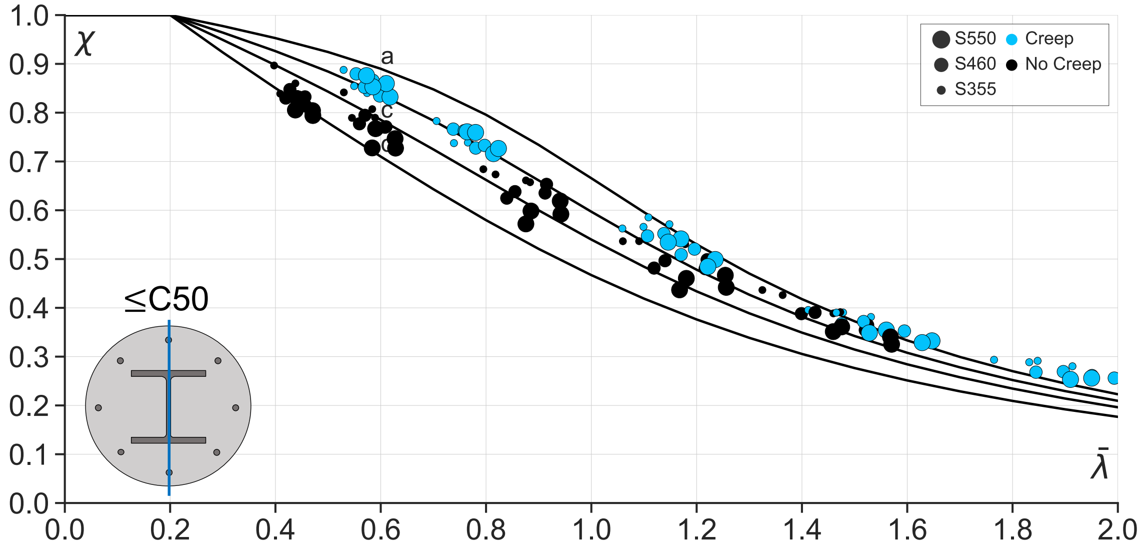


Figure 6.11. Centric Loaded Circular Sections with Normal Strength Concrete Bending about Weak Axis.

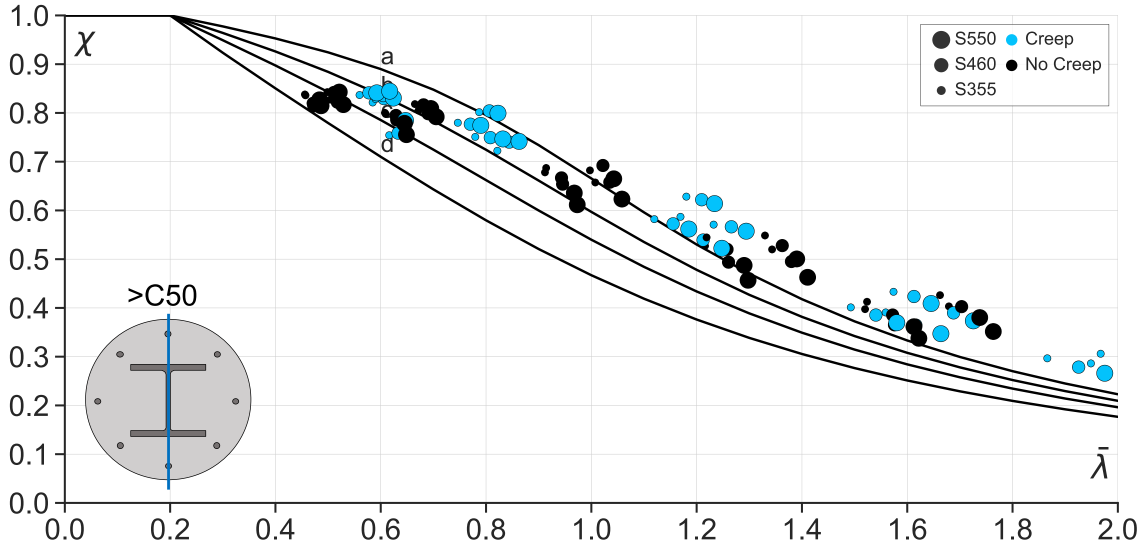


Figure 6.12. Centric Loaded Circular Sections with High Strength Concrete Bending about Weak Axis.

Figures 6.5 to 6.12 show the results from parametric study on centric loaded columns on European buckling curves. Sections are separated by axis of bending, concrete class and cross-section type. In each plot, black points represent absence of creep and blue points mean creep was considered. Considering creep increases the slenderness due to the reduction of modulus of elasticity of concrete in all cases so blue points are to the right of black points. For lower slenderness columns, creep increases the χ values due to better utilization of steel resistance with increased straining capacity of concrete. For higher slenderness, blue points have lower χ because of increased moment amplification and second order effects.

All plots show that points do not follow trend of any buckling curve. Therefore, it is not possible to classify the curves as it was intended. Classifying curves on low slenderness points would underestimate resistance for high slenderness points and vice versa. This finding encourages development of a new method in which buckling curves are not utilized.

One significant observation from the results plotted on buckling curves was, the points falling very high above buckling curves were always the columns with C90/105 concrete. Further investigation revealed that without exception, higher strength concrete increased the vertical distance of the points to buckling curves. The reason behind lies in the calculation of slender ratio value on the horizontal axis. $\overline{\lambda}$ is calculated by Equation 6.1, replacing other equations inside the equation follows:

$$\overline{\lambda} = \sqrt{\frac{A_a f_{yk} + A_s f_{sk} + 0.85 A_c f_{ck}}{\frac{\pi^2 EI_{eff}}{L^2}}} \tag{6.5}$$

$$EI_{eff} = E_a I_a + E_s I_s + 0.6 E_{c,eff} I_c \tag{6.6}$$

$$E_{c,eff} = E_{cm} \frac{1}{1 + \left(N_{G,Ed}/N_{Ed}\right) \varphi_t} \tag{6.7}$$

Writing E_{cm} and f_{ck} in terms of f_{cm} in acc. with Eurocode 2 and keeping all other terms constant and replacing with constant symbols:

$$\overline{\lambda} = \sqrt{\frac{C_1 + C_2 \left(f_{cm} - 8\right)}{C_3 + C_4 f_{cm}^{1/3}}} \tag{6.8}$$

The nonlinear relationship between nominator and denominator in Equation 6.8 is the reason of increasing slenderness ratio with increased concrete grade. Increased $\overline{\lambda}$ values on the buckling curves result with points falling wide above the buckling curve a and even higher than euler buckling curve which is not possible. It can be concluded that, this issue is another strong point against use of buckling curves for design of composite columns of high performance materials since it could overestimate resistance.

6.2. Equivalent Flexural Stiffness

Eurocode 4's method to calculate second order internal bending moment is given by Equation 6.9.

$$M_{Ed} = \frac{M_{Ed,Im} + \beta_M M_{Ed,Em}}{1 - N_{Ed}/N_{cr,eff}} \tag{6.9}$$

where:

$M_{Ed,Em}$ is the maximum column end moment

$M_{Ed,Im}$ is the maximum first order moment within the length of column including effect of imperfections

β_M is equivalent moment factor depending on moment ratio at the end of columns. It is equal to 1.1 when the end moments are equal.

$N_{cr,eff}$ is the critical buckling force calculated using $EI_{eff,II}$ which is given below.

$$EI_{eff,II} = 0.9\left(E_a I_a + E_s I_s + 0.5 E_{c,eff} I_c\right) \tag{6.10}$$

$$E_{c,eff} = \frac{E_{cm}}{1 + \left(N_{G,Ed}/N_{Ed}\right)\varphi_t}$$

where,

φ_t is the creep coefficient from Eurocode 2.

N_{Ed} is the total design normal force

$N_{G,Ed}$ is the permanent design normal force

In Figure 4.34, the background for use of $EI_{eff,II}$ instead of EI_{eff} in calculation of second order effects acc to Eurocode 4 was presented. $EI_{eff,II}$ will be used to calculate second order effects in this section. The proposed method considers a fixed initial bow imperfection of L/600 and resistance to be calculated on interaction curve for both axially and eccentrically loaded columns. The utilization is not calculated solely on the internal moment but on the force-moment vectors's proximity to the interaction curve. This approach is similar to that of general method of design for columns in Eurocode 4 in German National Annex. Considering only moments for the design control would be misleading especially for the zone where compression governs. The methodology for assessing the proposed method's accuracy is outlined in Figure 6.13.

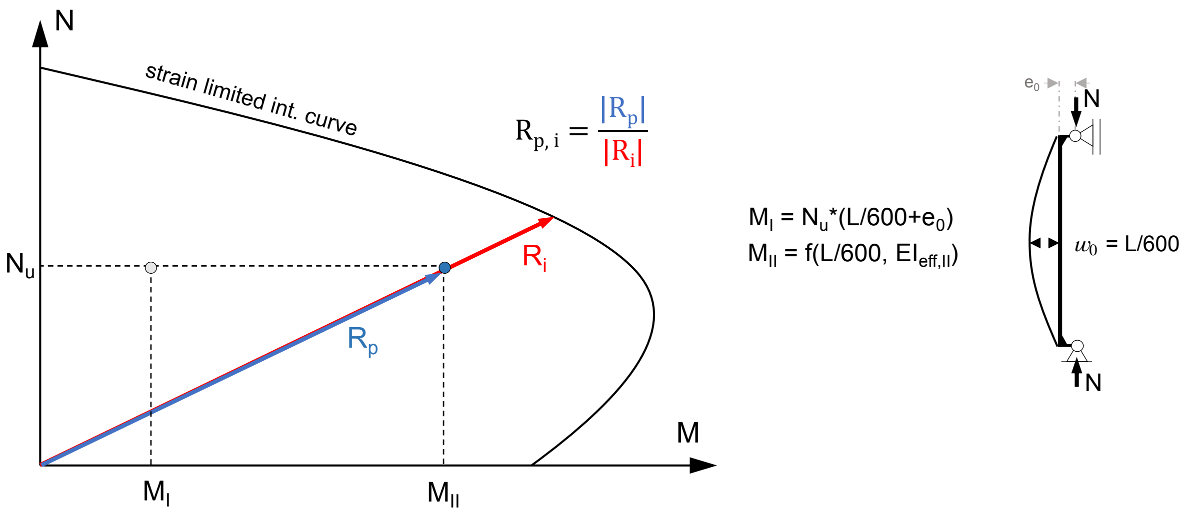
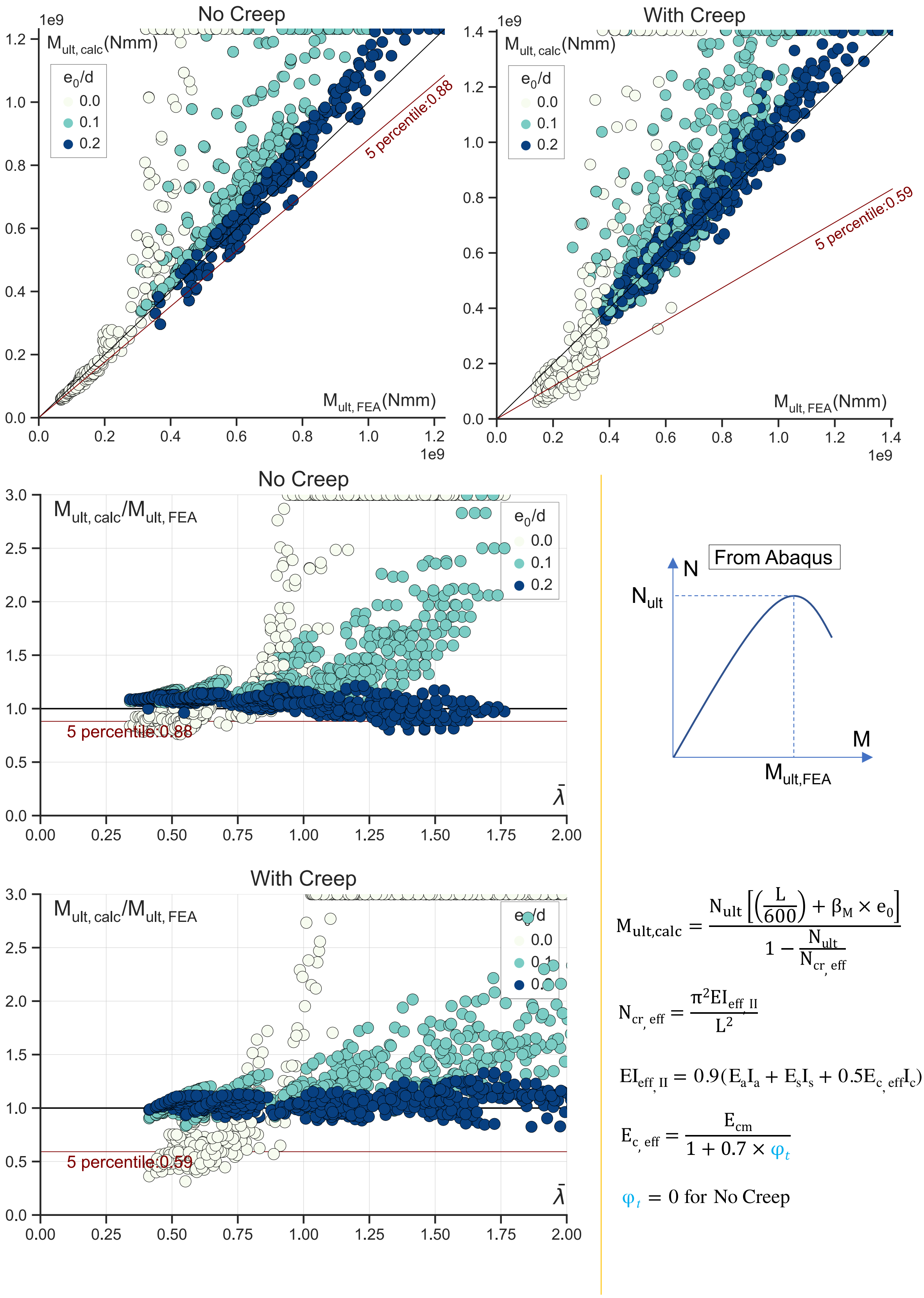


Figure 6.13. Calculation of ratio $R_{p,i}$ to assess proposed method

All the parametric study runs were performed with mean material strengths. Therefore, the assessment of the proposed equation's accuracy was also done on interaction curves with mean strengths. Figure 6.13 shows R_p as the vector from origin to the point with ultimate force from FE analysis and internal moment calculated by Eurocode 4's moment amplification using initial bow imperfection of L/600 for that ultimate force. R_i on the figure is the vector representing resistance, it extends from origin to the interaction curve aligned with R_p. The internal moment for each simulation was calculated using Equation 6.9 and not taken from FE results. $R_{p,i}$ is the ratio of the lengths of former to the latter. Its values greater than 1 imply points fall out of interaction curve and less than 1 imply points fall inside the interaction curve. For the values less than 1, the method is unsuccessful to capture the failure. Figures 6.14 to 6.17 show the $R_{p,i}$ for parametric study runs from Table 6 for different eccentricities with and without creep using $EI_{eff,II}$ and L/600. The interaction curves were developed using a strain limit of ϵ_{cu1} and were not modified by creep. Also the second order moments calculated by Eurocode 4's equation are compared with that from FEA for each parametric study run in the figures.



$$M_{ult,calc} = \frac{N_{ult}\left[\left(\frac{L}{600}\right) + \beta_M \times e_0\right]}{1 - \frac{N_{ult}}{N_{cr,\,eff}}}$$

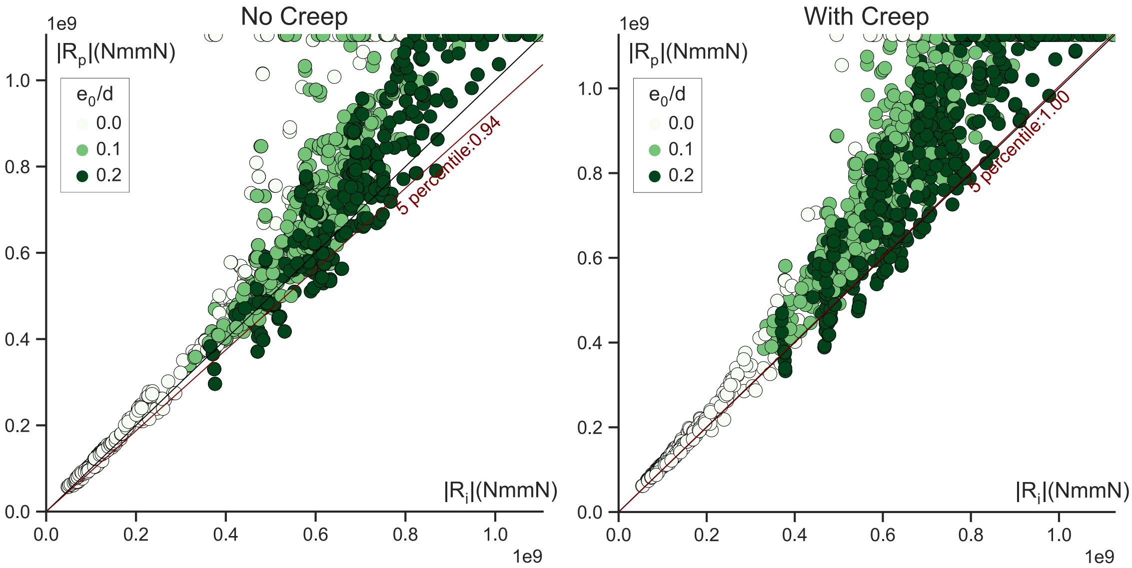
$$N_{cr,\,eff} = \frac{\pi^2 EI_{eff\ II}}{L^2}$$

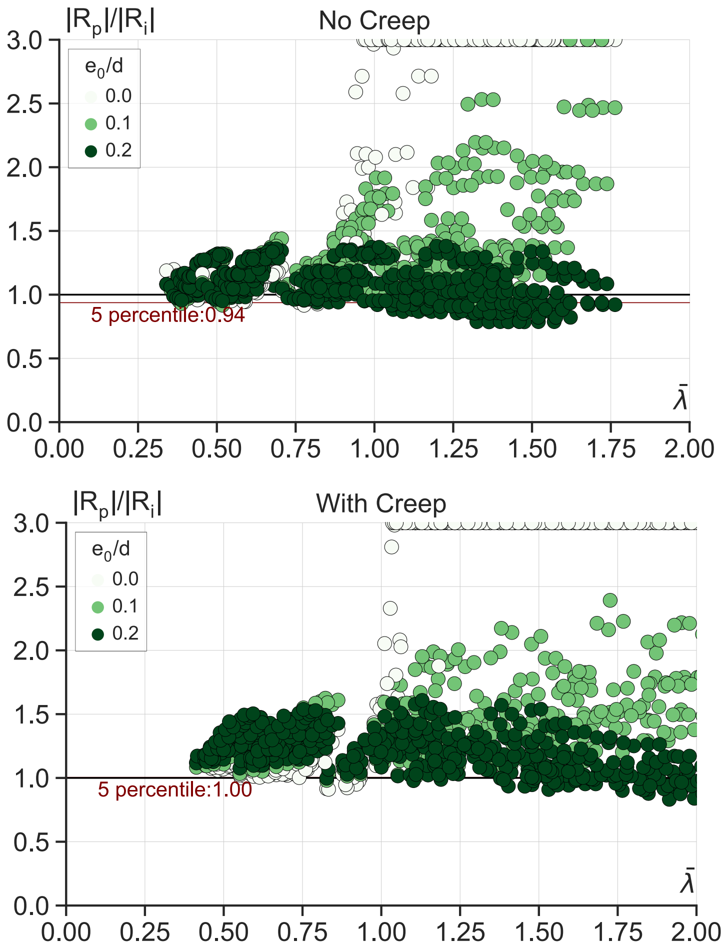
$$EI_{eff,\,II} = 0.9(E_a I_a + E_s I_s + 0.5 E_{c,\,eff} I_c)$$

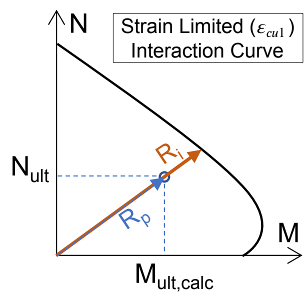
$$E_{c,\,eff} = \frac{E_{cm}}{1 + 0.7 \times \varphi_t}$$

$\varphi_t = 0$ for No Creep

Figure 6.14. Second order internal moment comparison for parametric study runs







$$M_{ult,calc} = \frac{N_{ult}\left[\left(\frac{L}{600}\right) + \beta_M \times e_0\right]}{1 - \frac{N_{ult}}{N_{cr,\,eff}}}$$

$$N_{cr,\,eff} = \frac{\pi^2 EI_{eff,\,II}}{L^2}$$

$$EI_{eff,\,II} = 0.9(E_a I_a + E_s I_s + 0.5E_{c,\,eff} I_c)$$

$$E_{c,\,eff} = \frac{E_{cm}}{1 + 0.7 \times \varphi_t}$$

$\varphi_t = 0$ for No Creep

Figure 6.15. Strain limited interaction curve utilization for parametric study runs

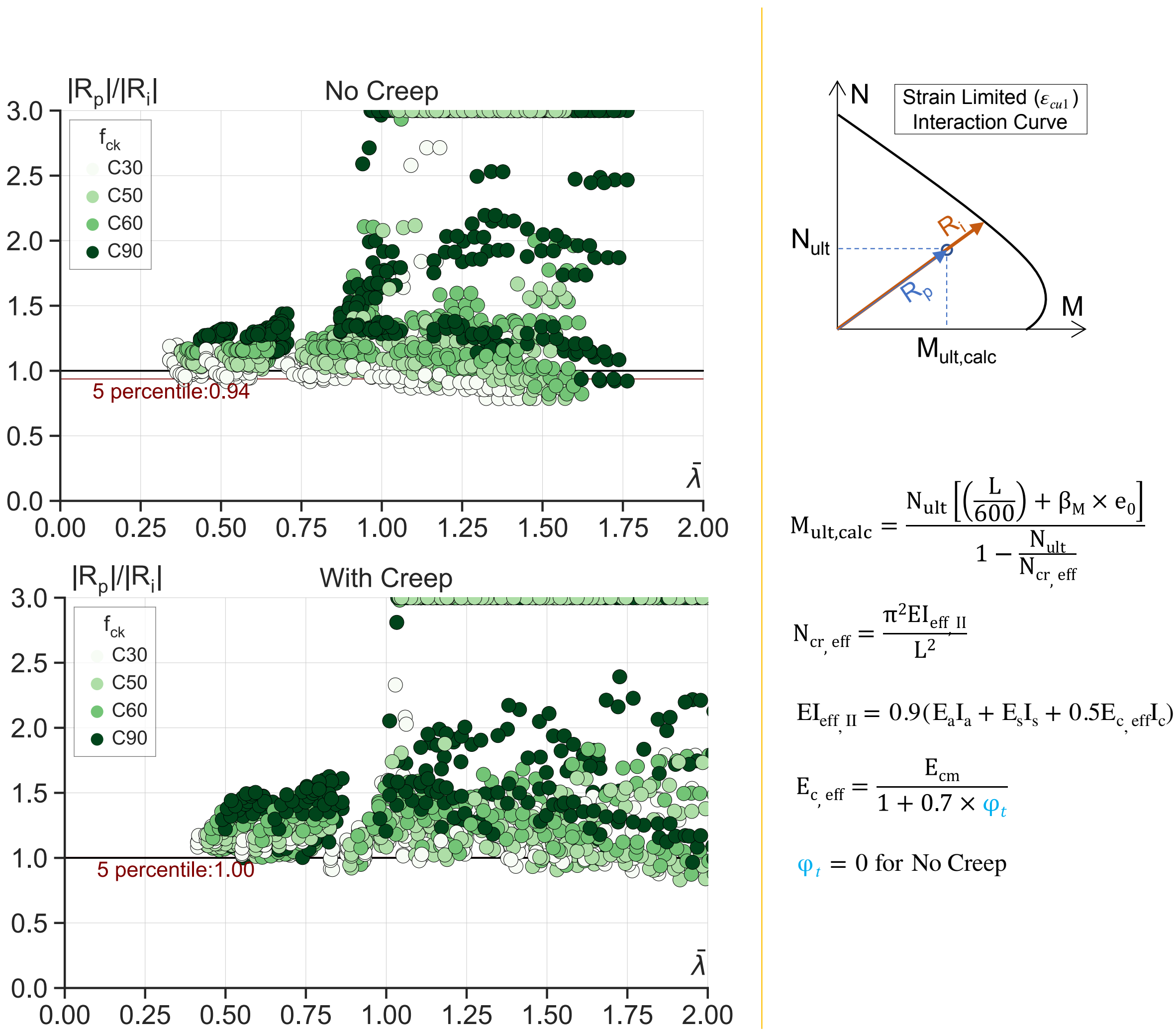
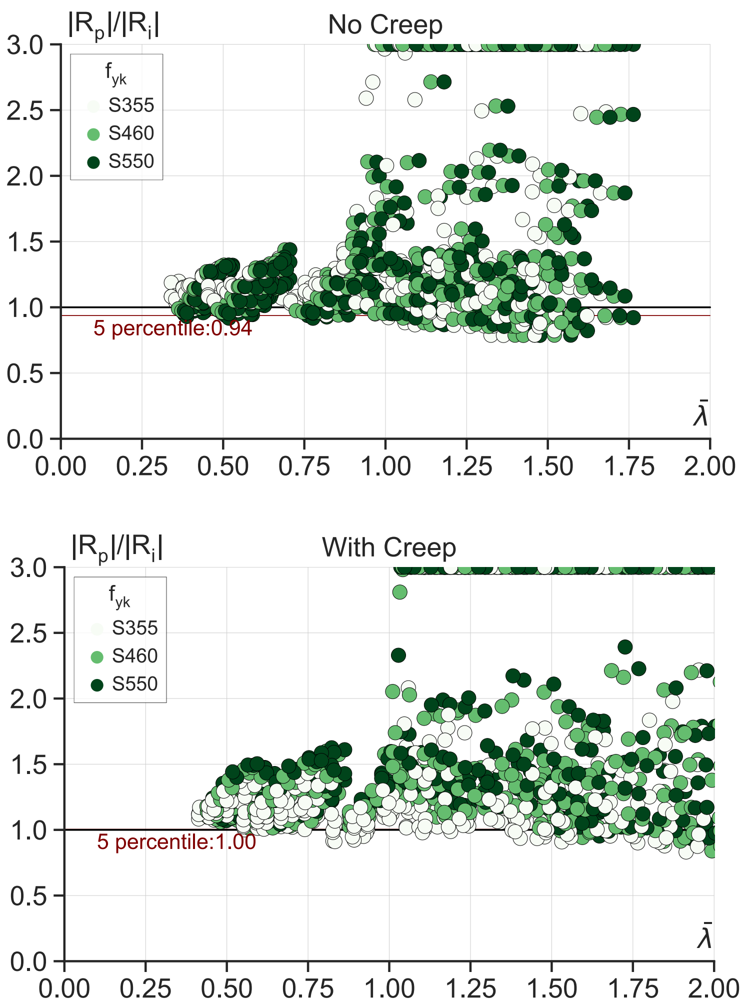
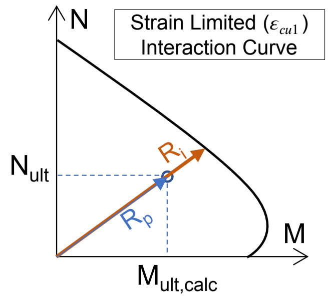


Figure 6.16. Strain limited interaction curve utilization for parametric study runs colored by f_{ck}





$$M_{ult,calc} = \frac{N_{ult}\left[\left(\frac{L}{600}\right) + \beta_M \times e_0\right]}{1 - \frac{N_{ult}}{N_{cr,\,eff}}}$$

$$N_{cr,\,eff} = \frac{\pi^2 EI_{eff\ II}}{L^2}$$

$$EI_{eff,\,II} = 0.9(E_a I_a + E_s I_s + 0.5 E_{c,\,eff} I_c)$$

$$E_{c,\,eff} = \frac{E_{cm}}{1 + 0.7 \times \varphi_t}$$

φ_t = 0 for No Creep

Figure 6.17. Strain limited interaction curve utilization for parametric study runs colored by f_{yk}

Figures 6.15 and 6.17 show most of $R_{p,i}$ values to be greater than 1. However, there are some points to be lower than 1. Also, for the centrically loaded columns, $R_{p,i}$ values get extremely large for slenderness greater than 1. Deeper observation of these cases revealed that the normal resistance obtained by FE analysis can exceed the critical buckling load obtained by the given equations on the figures from Eurocode. Which indirectly implies that the flexural stiffness values are underestimated for centrically loaded columns with slenderness ratio greater than 1. To overcome this issue, slight modification of $EI_{eff,II}$ equation is proposed. Many iterations revealed following modification to the equation gives a much better scatter of points for each eccentricity. Modification depends on concrete class and load eccentricity. Increased concrete class increases the flexural stiffness and increased eccentricity decreases the flexurall stiffness in the proposed modification. Lower class concrete has higher straining capacity and therefore loss of concrete stiffness at failure is larger than the higher class concrete. On the other hand, larger eccentricity causes section to crack more under bending effects as opposed to lower load eccentricity. These phenomena are in agreement with the proposed modification on the flexural stiffness equation to be used for internal second order moment calculation.

$$EI_{eff,II} = 0.9(E_a I_a + E_s I_s + 0.5 E_{c,eff} I_c)$$

$$EI_{eff,II,prop} = 0.9(E_a I_a + E_s I_s + C E_{c,eff} I_c)$$

C

		e/d		
		0	0.1	0.2
f_{ck}	C30	0.8	0.5	0.2
	C90	1	0.8	0.6

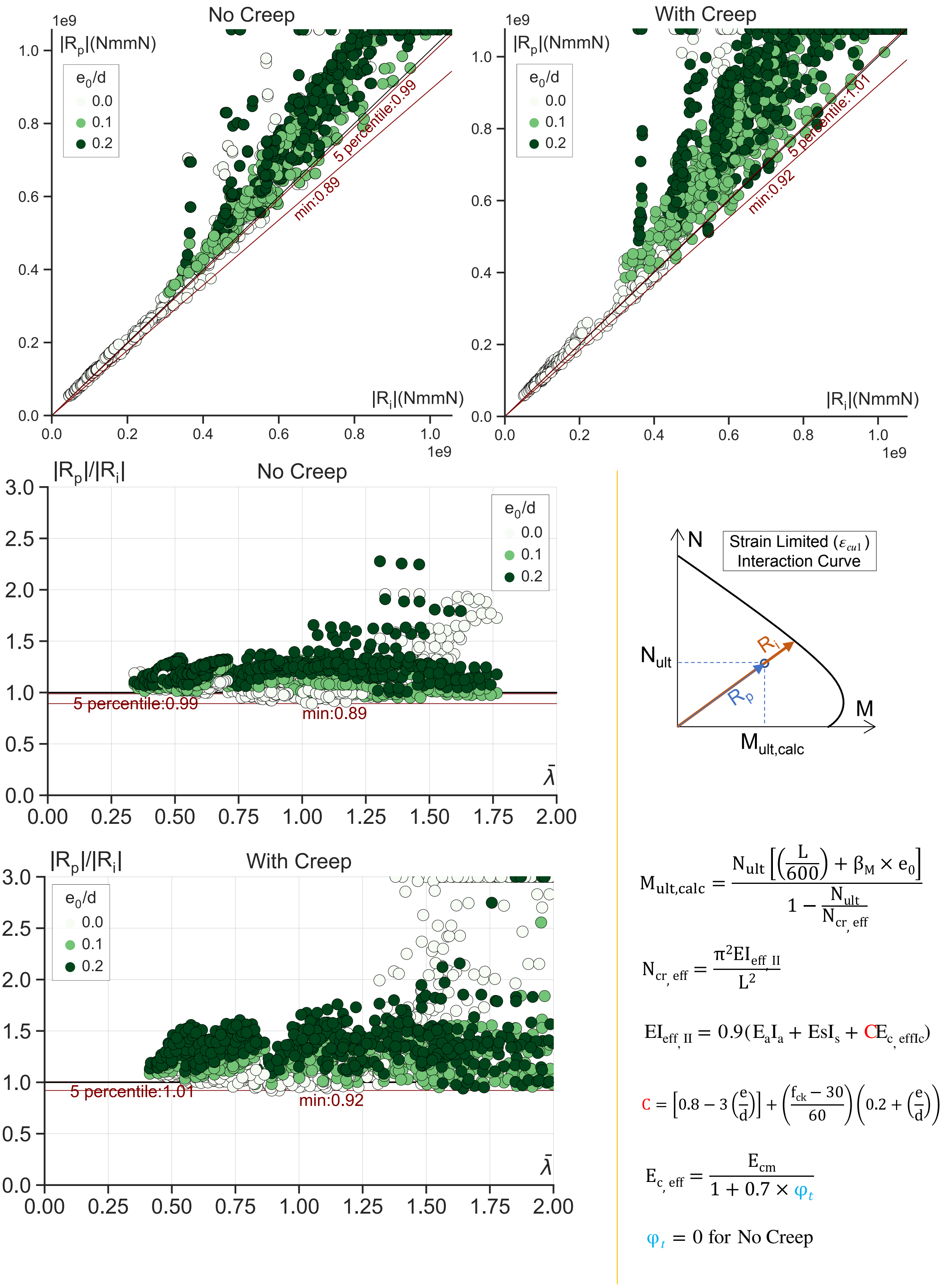
Figure 6.18. Proposed Modification to $EI_{eff,II}$

Linearly interpolating C values in Figure 6.18 for intermediate values yields Equation 6.11.

$$C = [0.8 - 3(e/d)] + [\left(\frac{f_{ck} - 30}{60}\right)(0.2 + (e/d))] \tag{6.11}$$

Applying the proposed modification given in Equation 6.11 to the results of parametric study in order to calculate $R_{p,i}$, the results shown in Figure 6.19 are obtained. The effect on non-eccentricity points is significant. For the case without creep, no points fall outside of the plot and overall the points are much closer to one. This is due to the increased flexural stiffness and therefore critical buckling load. Non-modified equation underestimated flexural stiffness and therefore yielded very large $R_{p,i}$ values.

Although in Figure 6.19, the points moved near one, the minimum values are still lower. This means, for some cases, the proposed method to calculate resistance considering second order effects is nonconservative. To overcome this issue, Proposed equation was also applied with increased initial bow imperfection value, L/400. The results with this modification are shown in Figure 6.20. For both without and with creep, minimum points are greater than or equal to one. Which means the method is conservative, thus safe-sided for every case.



$$M_{ult,calc} = \frac{N_{ult}\left[\left(\frac{L}{600}\right) + \beta_M \times e_0\right]}{1 - \frac{N_{ult}}{N_{cr,\,eff}}}$$

$$N_{cr,\,eff} = \frac{\pi^2 EI_{eff,\,II}}{L^2}$$

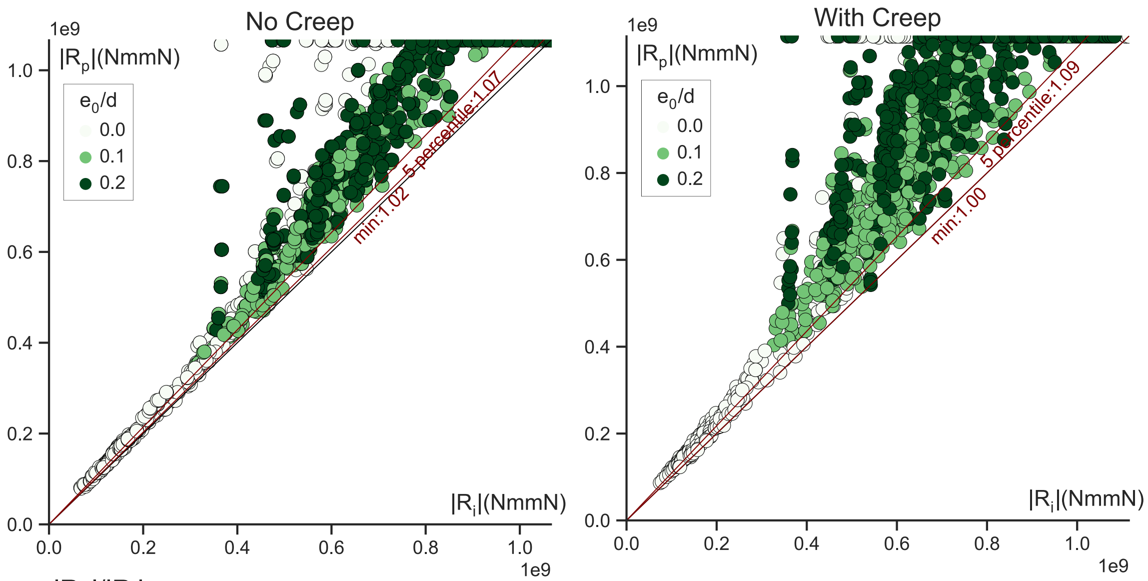
$$EI_{eff,\,II} = 0.9(E_a I_a + E_s I_s + C E_{c,\,effIc})$$

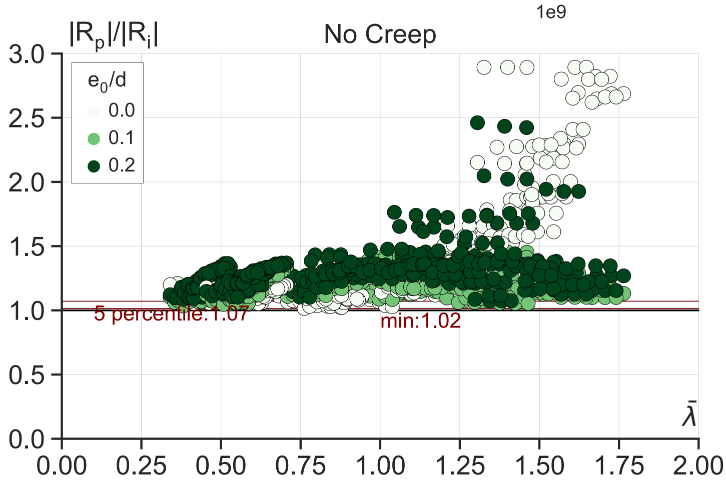
$$C = \left[0.8 - 3\left(\frac{e}{d}\right)\right] + \left(\frac{f_{ck} - 30}{60}\right)\left(0.2 + \left(\frac{e}{d}\right)\right)$$

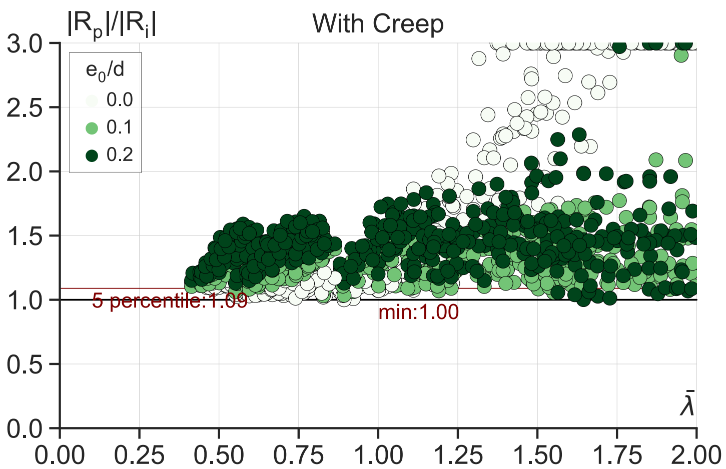
$$E_{c,\,eff} = \frac{E_{cm}}{1 + 0.7 \times \varphi_t}$$

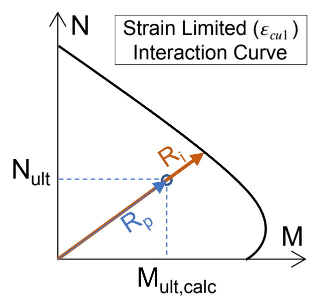
$\varphi_t = 0$ for No Creep

Figure 6.19. Strain limited interaction curve utilization for parametric study runs with modified flexural stiffness and imperfection of L/600









$$M_{ult,calc} = \frac{N_{ult}\left[\left(\frac{L}{400}\right) + \beta_M \times e_0\right]}{1 - \frac{N_{ult}}{N_{cr,\,eff}}}$$

$$N_{cr,\,eff} = \frac{\pi^2 EI_{eff,\,II}}{L^2}$$

$$EI_{eff,\,II} = 0.9(E_a I_a + EsIs + C E_{c,\,eff} Ic)$$

$$C = \left[0.8 - 3\left(\frac{e}{d}\right)\right] + \left(\frac{f_{ck} - 30}{60}\right)\left(0.2 + \left(\frac{e}{d}\right)\right)$$

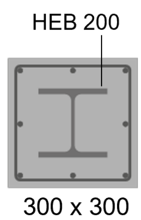
$$E_{c,\,eff} = \frac{E_{cm}}{1 + 0.7 \times \varphi_t}$$

$$\varphi_t = 0 \text{ for No Creep}$$

Figure 6.20. Strain limited interaction curve utilization for parametric study runs with modified flexural stiffness and imperfection of L/400

Up to now, only the sections created for parametric study were considered for the proposed initial bow imperfection of L/400 and proposed $EI_{eff,II,prop}$. To extend the proposed method's applicability on the relevant literature, previously mentioned work ob Bergmann and Lindner [17, 18] will also be considered. In the referenced work, concrete encased steel sections were classified as buckling curve b for strong axis bending and buckling curve c for weak axis bending. One of the sections used for the classification and fitted to the mentioned buckling curves is given in Figure. This section will be run with an FEA just as each run of the parametric study, and in the previous pages, R_p vs R_i and Lambda vs $R_{p,i}$ curves will be plotted. This is done in Figure 6.21.

Table 6.2. Section used by Bergmann and Lindner [17, 18] to classify concrete encased sections

Section & Profile	
Concrete Strength	C35
Profile Strength	S235
Reinf. Amount	4ϕ10 B420
Column Length (m)	3, 10
e/D (Load ecc. to Column Dimension)	0, 0.2
Bending Axis	Strong, Weak

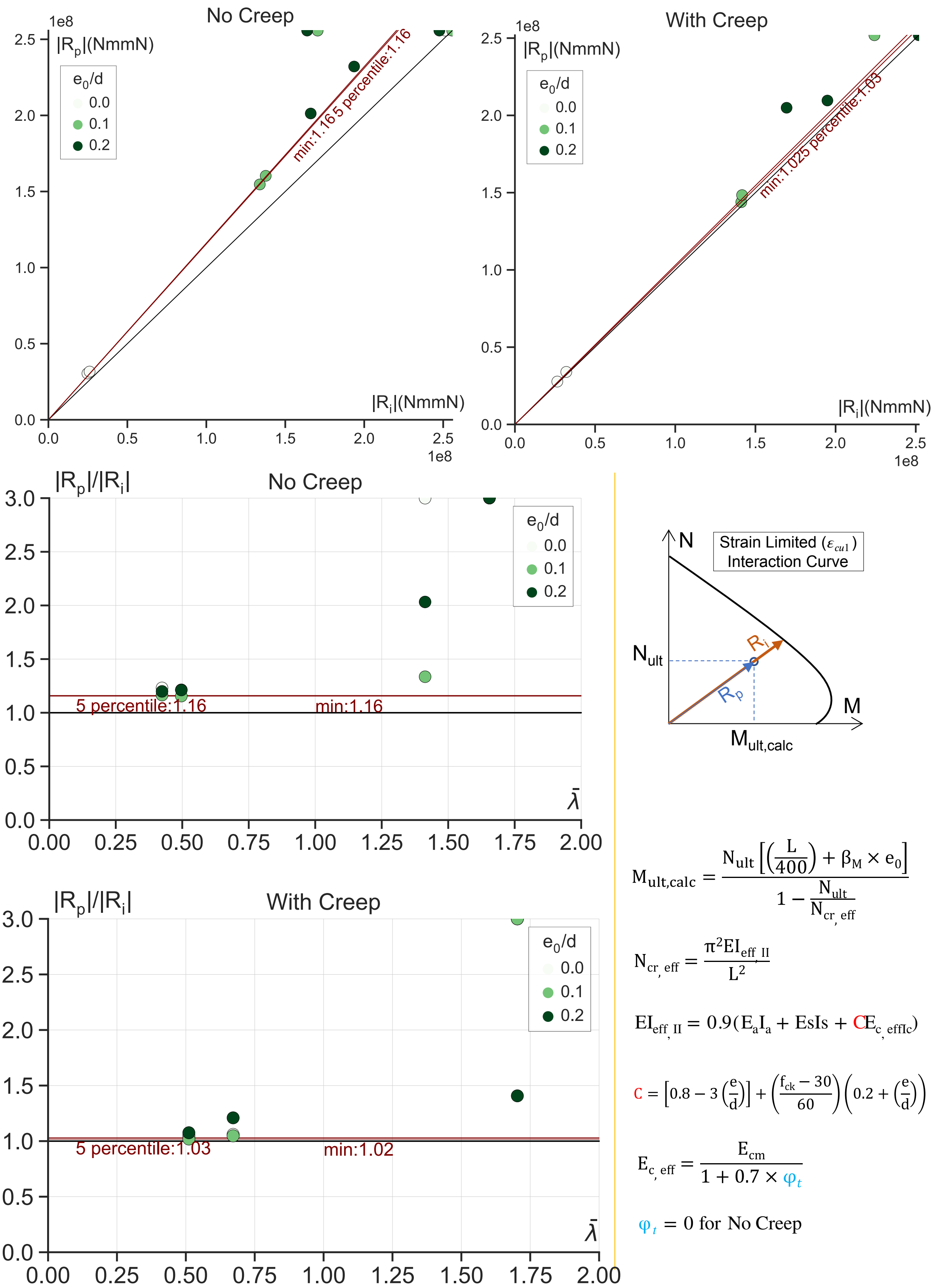


Figure 6.21. Strain limited interaction curve utilization for sections used for classification by Bergmann and Linder with modified flexural stiffness and imperfection of L/400

As seen in Figure 6.21, all of the considered cased with and without creep show $R_{p,i}$ values greated than one. Which means, even without the conservative classification and high equivalent initial imperfections, the proposed method for these columns show a safe sided resistance calculation.

6.2.1. Conclusion

In this section, second order effective flexural stiffness $EI_{eff,II}$ from Eurocode 4 was used to estimate second order internal moments from parametric study runs. Figure 6.14 shows the results for sections with HEB profiles, given in Table 6. One significant finding was that for the runs with creep, centrally loaded lower slenderness columns' internal bending moments were underestimated compared to FE results when calculated by $EI_{eff,II}$. Observing the data showed that the methodology to include creep effects for these columns resulted with much larger deflections than those without creep, increasing the moment amplification. This finding reinforces the notion that instead of only moment resistance calculation for columns under certain design load, use of mixed vector of moment and axial force can improve the accuracy and provide a safer approach. To test this, $R_{p,i}$ values are presented for the inputs of parametric study in Figures 6.15 to 6.17. The Figures show a safer approach over the scope of slenderness range as opposed to that for moments. One significant note about the cases with creep is that, creep effects were not used in obtaining interaction curve for those sections, hence the increase in values with creep. Since it is not expected for a designer to include creep in creation of interaction curve, this approach was chosen here for simplification.

Using $EI_{eff,II}$ from Eurocode 4 together with L/600 in calculating $R_{p,i}$ values showed for the normally loaded columns, the $R_{p,i}$ values to be very large. This was due to fact that the resistance calculated by finite element analysis exceeding the critical buckling load. Since critical buckling load only depend on flexural stiffness and column length, the conclusion was that for slender normally loaded columns, $EI_{eff,II}$ from Eurocode 4 was underestimated. This is in line with beam-column behaviour since normally loaded columns are not expected to undergo large deflections and significant cracking over the section. Another observation was that for higher eccentrically loaded columns where bending effects are more significant, the $R_{p,i}$ values fell below one, implying an underestimation of flexural stiffness. Following these observations, the part of flexural stiffness equation where the effect of cracking on concrete is reflected is proposed to be modified with values given in Figure 6.18 and Equation 6.11. In the proposed equation, together with eccentricity, concrete class has also an effect on the cracking. With increased concrete class, cracking becomes less pronounced. Reason behind being that higher class concrete has a lower strain limit (ϵ_{cu1}) therefore deflects less at maximum load capacity and undergoes less cracking.

With the proposed modifications on flexural stiffness equation used together with imperfection of L/600, an improvement on points in terms of proximity to 1 was observed. However, some points were lower than 1, meaning a nonconservative method. To overcome this, the proposed change was also applied with an increased bow imperfection of L/400. Result was all points being equal or greater than 1. Therefore a safe approach. To conclude, $EI_{eff,II,prop}$ shall be used with L/400 with proposed methodology in this dissertation together with strain limited interaction diagram for normally and eccentrically loaded encased columns to obtain resistance considering moment amplification for columns fitting in the scope hereby, concrete classes C30/37 to C90/105, steel grades S355 to S550, reinforcement classes B500 to B700 and eccentricity ratio of 0 to 0.2.

6.3. Fully Plastic vs Strain Limited Interaction Curves

The proposed design method uses strain limited interaction curve for resistance calculation of columns. However, current Eurocode 4 assumes fully plastic section resistance when calculating the interaction curve. Since the fully plastic section assumption is widely accepted and in use, in this section, a new methodology is proposed to allow designers also use fully plastic interaction curves.

Current Eurocode 4 uses reduction factors α_M when calculating moment resistance of columns on interaction curves. This is to account for the possibility that fully plastic section assumption is in reality not observed. α_M values depend solely on the steel grade used for the profile. Considering that concrete material strength is limited to up to C50/60, this is not an issue. However, proposed method aims for allowing concrete up to C90/105 and it is known that concrete's straining capacity is affected by its strength class, a reduction factor only based on steel grade will not suffice. Therefore, a reduction factor is proposed to be based on both concrete class and steel grade.

Current Eurocode 4 reduces the plastic resistance from interaction curve which aligns with the design point horizontally. Although this is possible for the regions with relatively high moments, some material combinations will not allow this to be applied for regions of low moments and high axial force. This is due to the risk that axial force resistance calculated by strain limitation being lower than that calculated by fully plastic section. This is outlined in Figure 6.22.

A new reduction factor, called α_{MN} is proposed to be used on interaction curves with fully plastic section assumption. It shall be applied to the resistance vector and accounts for not reaching the full plasticity at failure. To determine α_{MN} to be used in design, sections from the parametric study are used. Interaction curves for them were created using design resistances for both strain limited and fully plastic cases. Changing the angle θ in Figures 6.23 and 6.24 from 0 degrees to 90 degrees with an interval of 1 degree, the minimum α_{MN} for each section is calculated. After completing this for all sections and observing the results, it was noticed that minimum values are always obtained where bending moment is very high, in other words, lower parts of the interaction curves governed the minimum values. Using those values also for the cases where bending moment is nonsignificant would be very conservative. Therefore, the curves were divided into two sections. A section where N_{Ed} would be less than $0.5N_{plRd}$ and another section where it would be higher. Latter section resulted with less reduction in capacity from plastic to strain limited. This is illustrated in Figures 6.23 and 6.24 and the obtained values are then presented based on material combinations for both sections of the interaction curves.

Used sections for determining α_{MN} are shown on Table 6.3.

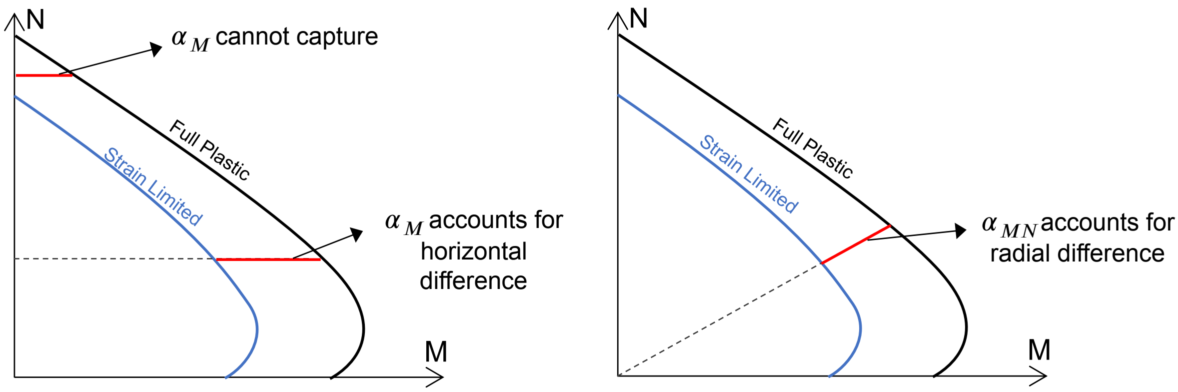


Figure 6.22. Reduction factor α_M vs α_{MN}

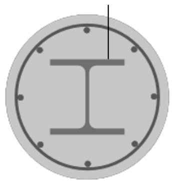
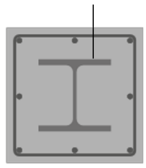
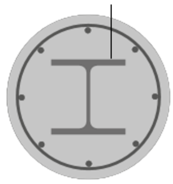
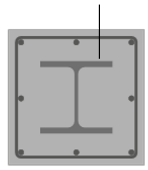
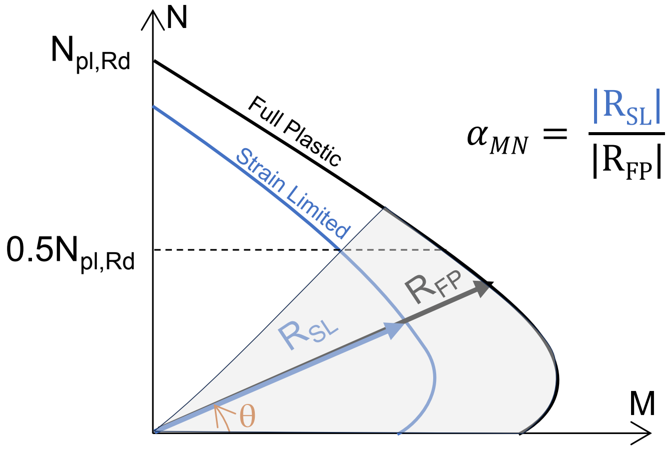
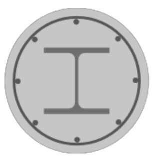
Section & Profile	HEB 220  d450 HEB 220  400 x 400	HEM 300  d600 HEM 300  500 x 500
Concrete Strength	C30, C50, C60, C90	C30, C90
Profile Strength	S355, S460, S550	S355, S550
Reinf. Amount	8ϕ14 B500, 8ϕ25 B700	8ϕ14 B500, 8ϕ25 B700
Bending Axis	Strong, Weak	Strong, Weak
Samples	2 x 4 x 3 x 2 x 2 = 96	2 x 2 x 2 x 2 x 2 = 32

Table 6.3. Sections Used to Determine min α_{MN} Values

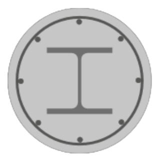


for θ with 1° intervals
min α_{MN} is obtained for each section

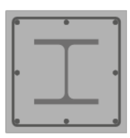
minimums of min α_{MN}

		Steel Grade		
		S355	S460	S550
Concrete Class	C30	0.78	0.74	0.58
	C50	0.83	0.76	0.70
	C60	0.83	0.77	0.71
	C90	0.80	0.79	0.65

averages of min α_{MN}

		Steel Grade		
		S355	S460	S550
Concrete Class	C30	0.85	0.80	0.69
	C50	0.85	0.82	0.76
	C60	0.85	0.83	0.77
	C90	0.86	0.84	0.77

minimums of min α_{MN}

		Steel Grade		
		S355	S460	S550
Concrete Class	C30	0.83	0.77	0.64
	C50	0.85	0.80	0.75
	C60	0.86	0.81	0.76
	C90	0.85	0.82	0.71

averages of min α_{MN}

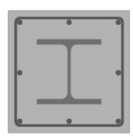
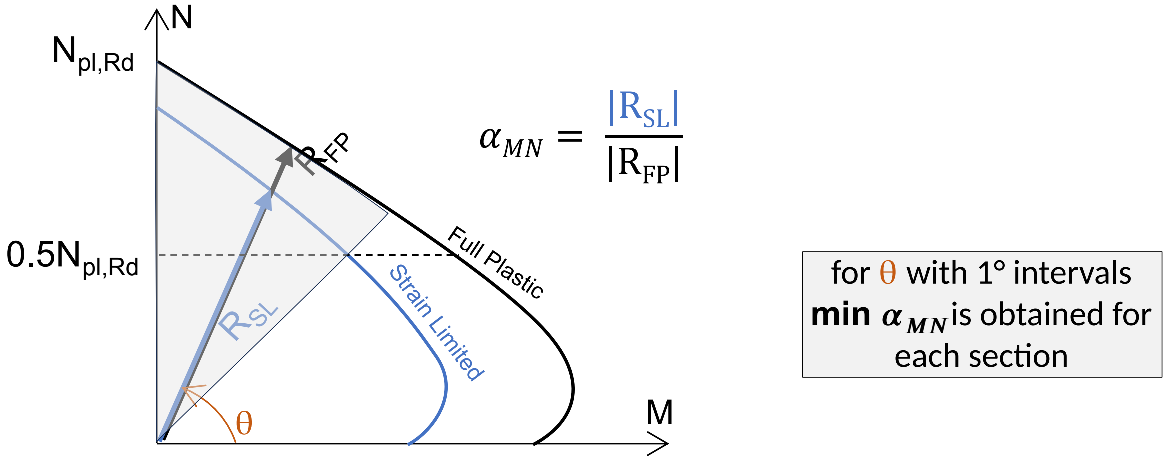
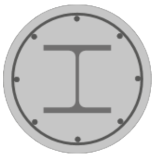
		Steel Grade		
		S355	S460	S550
Concrete Class	C30	0.88	0.85	0.78
	C50	0.88	0.85	0.82
	C60	0.89	0.86	0.83
	C90	0.89	0.87	0.83

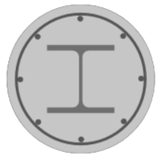
Figure 6.23. Calculated α_{MN} Reduction Factors to Apply on Fully Plastic Interaction Curves for $N_{Ed} < 0.5N_{pl,Rd}$



minimums of min α_{MN}

		Steel Grade S355	S460	S550
Concrete Class	C30	0.82	0.77	0.68
	C50	0.84	0.79	0.73
	C60	0.84	0.79	0.74
	C90	0.85	0.81	0.75

averages of min α_{MN}

		Steel Grade S355	S460	S550
Concrete Class	C30	0.88	0.83	0.79
	C50	0.88	0.85	0.80
	C60	0.88	0.85	0.80
	C90	0.89	0.86	0.82

minimums of min α_{MN}

		Steel Grade S355	S460	S550
Concrete Class	C30	0.86	0.80	0.72
	C50	0.88	0.83	0.77
	C60	0.88	0.84	0.78
	C90	0.88	0.85	0.78

averages of min α_{MN}

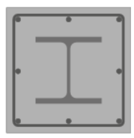
		Steel Grade S355	S460	S550
Concrete Class	C30	0.90	0.87	0.83
	C50	0.90	0.88	0.85
	C60	0.91	0.89	0.85
	C90	0.92	0.89	0.86

Figure 6.24. Calculated α_{MN} Reduction Factors to Apply on Fully Plastic Interaction Curves for $N_{Ed} \geq 0.5N_{pl,Rd}$

Figures 6.23 and 6.24 present the results of the extensive analysis on plastic and strain limited interaction curves. Sections are separated as circular and square. Minimums of obtained minimum α_{MN} values as well as averages of them are given. Two avoid any non-conservative outcomes, minimums are proposed to be taken as reference. Although there are outliers, general trend is that reduction gets significant with increasing steel grade. Increased concrete class has less impact in comparison. With these values, the designer can choose which combination of materials to be used in design based on strain limited interaction curves without the need for calculating strain limited interaction curves. Columns where bending moments are not significant, the reductions are also less significant and being able to use lower α_{MN} values for those sections enable economical solutions.

6.4. Conclusion

In this chapter, a novel, strain limited design method for concrete encased steel columns of normal and high strength steel and concrete is established. An extensive parametric study using Abaqus modelling concrete encased steel columns with geometric, material, physical nonlinearities and imperfections was conducted. Results of the parametric study was first used to show the columns on buckling curves. It was not possible to classify these columns consistently on buckling curves. Buckling curves were developed for steel columns and are very strong tools for design of steel columns, but concrete encased steel sections' failure is governed by concrete, therefore they behave fundamentally different than steel columns.

A new methodology is presented in which strain limited interaction curves are used for design. The proposed strain limitation is ϵ_{cu1} from Eurocode 2 (FprEN 1992-1-1). Interaction curves shall be used in design of encased sections not only for eccentrically loaded columns but also normally loaded columns, unlike current simplified method of Eurocode 4. The initial bow imperfection to be used in nonlinear FEA is proposed to be L/600. For the resistance calculation on interaction curves, L/400 shall be used when calculating second order action effects on column cross section. Current $EI_{eff,II}$ in Eurocode 4 shall be replaced with Equation 6.11, which takes into account differences on strain capacity of normal and high strength concrete. The proposed method is shown to safely calculate resistance on 2880 cases of parametric study. With a bow imperfection of L/400 and effective flexural stiffness of Equation 6.11, all of the internal moment & normal force combinations fell out of the strain limited interaction curve, as shown in Figure 6.20.

Finally, a novel method is proposed to conservatively convert fully plastic interaction curves to strain limited interaction curves. Ideally, the designer is expected to create strain limited interaction curves for the columns in scope of this work, but plastic section assumption is already established in practice for composite column design. Therefore, with the proposed method in this chapter, the designer can either continue using plastic section assumption with conversion, or create strain limited interaction curves for resistance calculation.

The scope of the method is limited to geometrical spacing requirements, reinforcement ratio requirements and steel contribution requirements of Eurocode 4.

7. BIAXIAL BENDING

It was previously mentioned that Eurocode 4's method to combine biaxial bending causes overly conservative results for circular encased sections. In Chapter 4, the considered tests from the literature [1] were modelled using current Eurocode 4's methodology of combining biaxial bending and it was shown that the results were too conservative. In this chapter, a methodology to compute biaxial bending surface for any arbitrary bending angle will be presented. To do this, a software was developed to calculate a 3d interaction surface for encased sections. This software is then used to create an analytical formula for calculation fo interaction surfaces for biaxial bending. This way, a designer can use the proposed methodology to calculate a realistic interaction surface, therefore does not have to be limited to overly conservative biaxial bending resistances for the typologies considered. In section 7.1, the developed software is presented conceptually. In section 7.2, development of the analytical equation using the developed software is explained. In section 7.3, Eurocode 4's general method is investigated for biaxial bending for some biaxial design cases, using the results, a proposal is made for biaxial bending design in general method of Eurocode 4.

7.1. Software for Biaxial Interaction Surface Generation

A Python script was developed to obtain interaction surfaces of sections. The script assumes top fiber in the compression zone to crush at the ultimate load under a strain of ϵ_{cu1}. For different levels of axial force, neutral axis depth is found and then the moment capacity of the section corresponding to that axial force is calculated. This is repeated for different axial force levels as well as different angles of neutral axis positioned acc. to. the major principal axis. Procedure is illustrated in Figure 7.1. Obtained 3D surface is shown in Figure 7.2. A total of 84 points form the surface with 12 axial load levels. For each load level, a top view of the horizontal slice show the biaxial failure line as a combination of moments about major and minor bending axes.

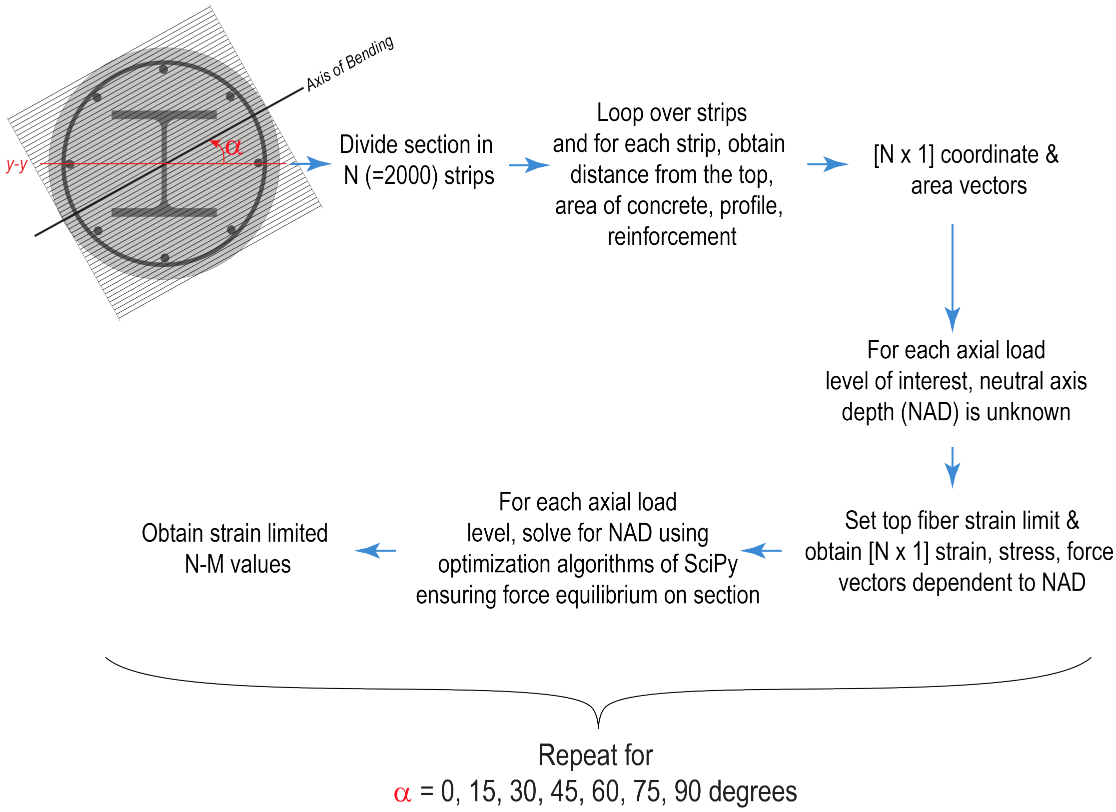


Figure 7.1. Steps to Create Biaxial Interaction Surface

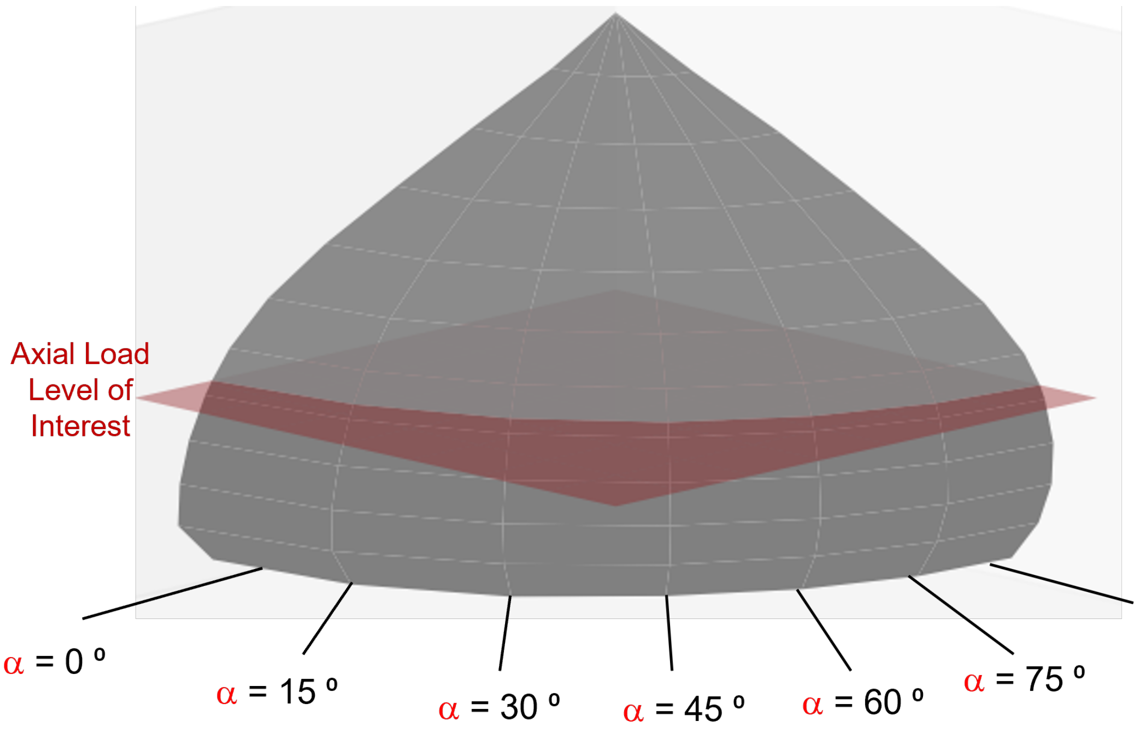


Figure 7.2. Biaxial Interaction Surface

The developed software will be used in the next sections to develop an equation enabling designer to calculate biaxial bending interaction surfaces without use of a software.

7.2. Proposed Method to Analytically Calculate Biaxial Interaction Surfaces

To be able to use the proposed method in Chapter 6, for biaxial bending, the designer has to be able to calculate the biaxial interaction curve under combination of biaxial internal bending moments. Then, they will be able to calculate the radial vector lengths R_p and R_i for design check. This is a tedious task without existance of a software developed for that purpose. Therefore, in the next paragraphs, a method will be presented to calculate the intermediary biaxial bending curve making an angle α from the major bending axis knowing the interaction curve for major and minor axes. The designer has to create interaction curve for major and minor axes themselves and with the proposed equation, it will be possible to combine them biaxially.

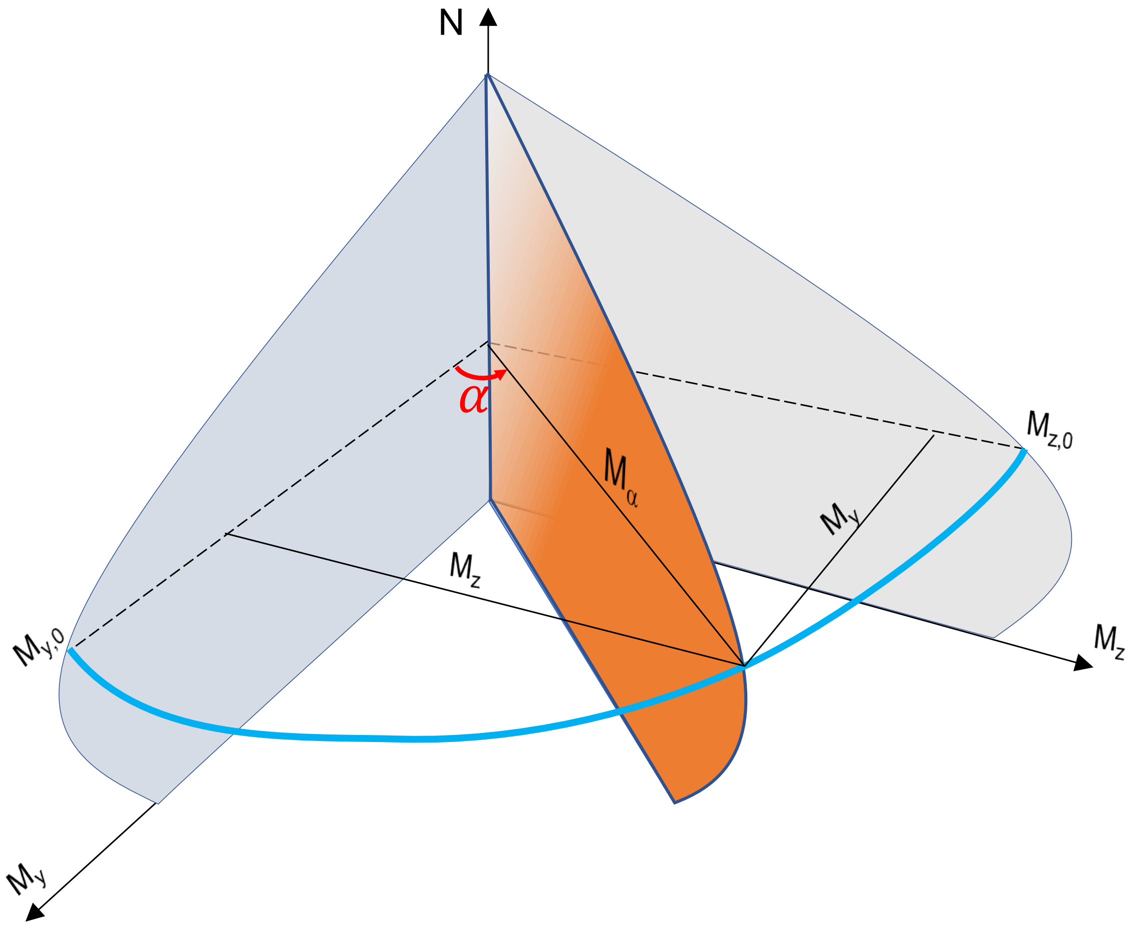


Figure 7.3. Interaction Curve for Biaxial Bending

In Figure 7.3, the purpose is visually presented. M_α needs to be written in terms of $\alpha, M_{y,0}, M_{z,0}$ for the axial load level of interest. For this, an analytical relationship has to be established between M_y, M_z and $M_{y,0}, M_{z,0}$ over each horizontal slice along the blue curve. Current method of Eurocode 4 establishes this relationship as in equation 7.1. As previously mentioned, this is a too conservative assumption.

$$\frac{M_y}{M_{y,0}} + \frac{M_z}{M_{z,0}} = 1 \tag{7.1}$$

To replace Equation 7.1 with a more efficient and accurate alternative, sections from the parametric study will be used to calculate interaction surfaces. For each section, interaction surface is created for discrete points. Then, for each point that lie between both principal axes, Equation 7.2 will be solved for β. Smallest β obtained from all points for that section will form a lower bound for the discrete points. This smallest β is proposed to be used for calculating M_α. This is illustrated in Figure 7.4. Choosing smallest β assures an inner bound for each surface created as illustrated in Figure 7.5.

$$\left[\frac{M_y}{M_{y,0}}\right]^\beta + \left[\frac{M_z}{M_{z,0}}\right]^\beta = 1 \tag{7.2}$$

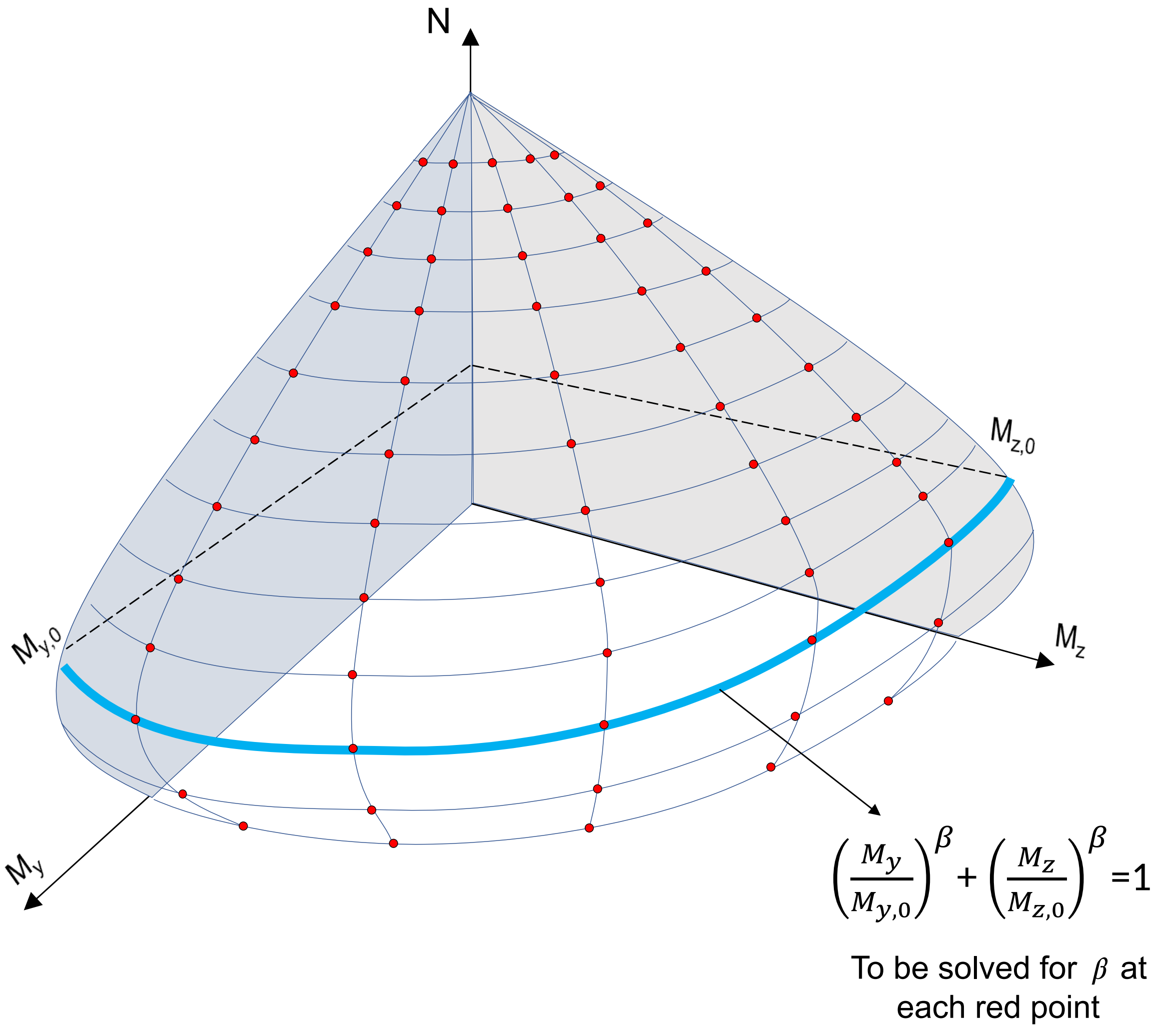


Figure 7.4. Equation for Biaxial Bending

With known β, calculation of M_α as a function of $\alpha, M_{y,0}$ and $M_{z,0}$ is presented below.

From Figure 7.3:

$$M_y = M_\alpha \cos\alpha \qquad \textbf{and} \qquad M_z = M_\alpha \sin\alpha \tag{7.3}$$

Inserting into Equation 7.2:

$$\left(\frac{M_\alpha \cos\alpha}{M_{y,0}}\right)^\beta + \left(\frac{M_\alpha \sin\alpha}{M_{z,0}}\right)^\beta = 1 \tag{7.4}$$

$$(M_\alpha)^\beta \left[\left(\frac{\cos\alpha}{M_{y,0}}\right)^\beta + \left(\frac{\sin\alpha}{M_{z,0}}\right)^\beta\right] = 1 \tag{7.5}$$

$$(M_\alpha)^\beta = \left[\left(\frac{\cos\alpha}{M_{y,0}}\right)^\beta + \left(\frac{\sin\alpha}{M_{z,0}}\right)^\beta\right]^{-1} \tag{7.6}$$

$$M_\alpha = \left[\left(\frac{\cos\alpha}{M_{y,0}}\right)^\beta + \left(\frac{\sin\alpha}{M_{z,0}}\right)^\beta\right]^{\frac{-1}{\beta}} \tag{7.7}$$

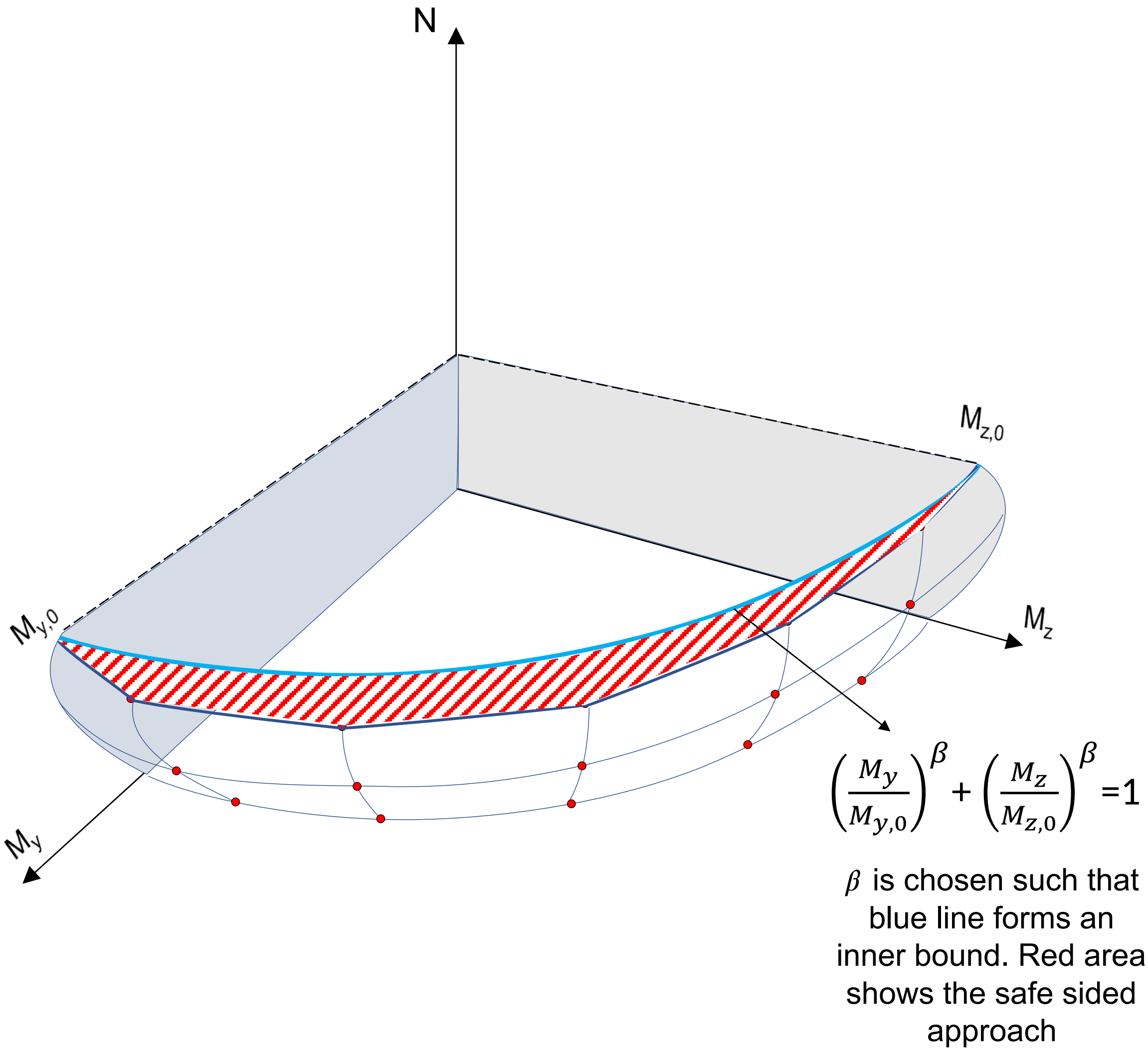
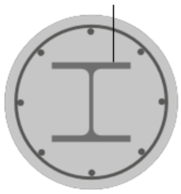
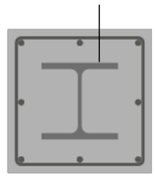
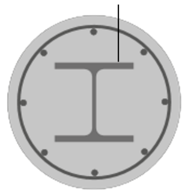
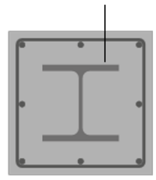


Figure 7.5. Proposed Equation Forming an Inner Bound to the Surface

Equation 7.7 allows for calculating moment capacity at an arbitrary angle α from major axis provided that moment capacities for major and minor axes are known. β value depends on the shape of the section under consideration. Solving for it for the sections given in Table 7.2 from parametric study resulted with values shown in Figure 7.6.

Table 7.1. Sections for β Calculation

Section & Profile	HEB 220  d450 — HEB 220  400 x 400	HEM 300  d600 — HEM 300  500 x 500
Concrete Strength	C30, C50, C60, C90	C30, C90
Profile Strength	S355, S460, S550	S355, S550
Reinf. Amount	8ϕ14 B500, 8ϕ25 B700	8ϕ14 B500, 8ϕ25 B700
Samples	2 x 4 x 3 x 2 = 48	2 x 2 x 2 x 2 = 16

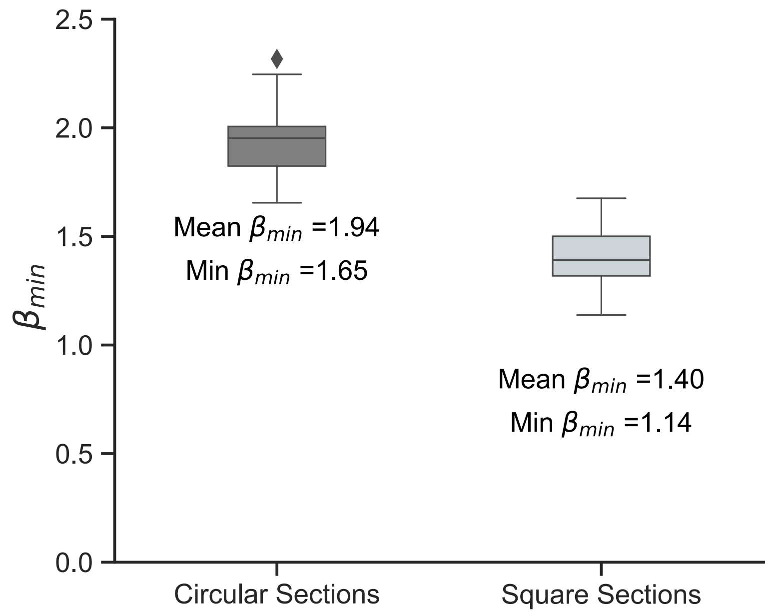


Figure 7.6. Distribution of Minimum β Values Obtained for Each Section

Since the proposed design method foresees creating the interaction curves without considering creep, β_{min} values were obtained without considering creep. Distribution of values for different sections is outlined in Figure 7.6. Proposed value for circular sections following these findings is 1.65 and for rectangular sections 1.14. The data created and used for Figure 7.6 is listed for 64 sections is given in Annex B.

7.3. Biaxial Bending in General Method of EN 1994-1-1

General method of Eurocode 4 covers the design of composite columns of arbitrary sections, meaning those not covered by the simplified method. The method requires use of an advanced finite element analysis for the column. With the FE, the column will be simulated using mean material resistances until failure to obtain load deflection curve at the critical section. To obtain the design resistance, interaction curves are used. Interaction curves for mean and design resistances have to be created. Then, the ratio of vector length from origin to mean interaction curve to the vector length from origin to design interaction curve is the overall safety factor γ_0. The ultimate resistance force obtained from FE analysis is then divided by γ_0 to obtain design resistance in acc with general method of Eurocode 4. This procedure is outlined in Figure 7.7.

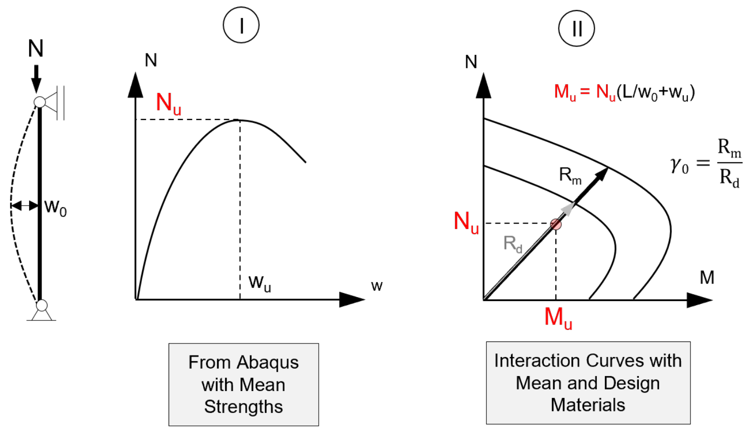
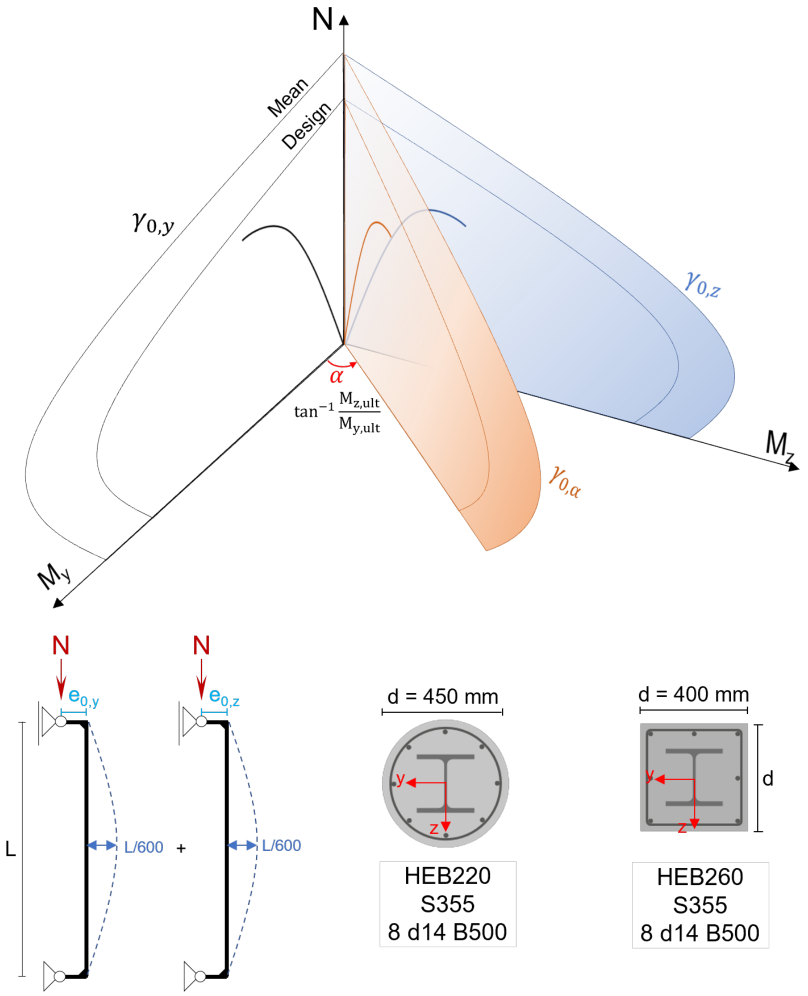


Figure 7.7. Overall Safety Factor in General Method of EC4 for Uniaxial Bending

General method's use is clear for uniaxial bending. However, there is no specification or guidance for biaxial bending. The advanced finite element analysis can be done with corresponding load eccentricities leading to biaxial bending. How to calculate the γ_0 for biaxial bending is unknown. To propose an approach, the developed software by the author for creating biaxial interaction surfaces is used. The software enables to create interaction curves for arbitrary bending moment axes. Several sections as in Table with given load eccentricities are modelled using FE analysis. Because of biaxial setting of loading. Deflections in both major and minor axes are recorded. This allowed to obtained force resistance N_{ult} as well as ultimate bending moments about major and minor axes, $M_{y,ult}$ and $M_{z,ult}$, respectively. Three different γ_0 values are calculated, $\gamma_{0,y}$ about major axis, $\gamma_{0,\alpha}$ about rotated axis and $\gamma_{0,z}$ about minor axis. The variation between the three values for each case is presented finally. All the inputs and outputs are given in Figure 7.8.

Looking at the last three columns of the Table at Figure 7.8, one can see that for all of the rows, $\gamma_{0,\alpha}$ values are lower than $\gamma_{0,y}$ and $\gamma_{0,z}$. This means, using the biaxial interaction surface would enable more utilization of the column capacity. It also means that using smaller of $\gamma_{0,y}$ and $\gamma_{0,z}$ for design is on the safe side.



No	Section	L (mm)	Concrete	$e_{0,y}/d$	$e_{0,z}/d$	N_{ult} (N)	$M_{y,ult}$ (Nmm)	$M_{z,ult}$ (Nmm)	α (deg)	$\gamma_{0,y}$	$\gamma_{0,\alpha}$	$\gamma_{0,z}$
1	Circular	3000	C50	0.1	0.1	5993	335	342	45.6	1.51	1.50	1.55
2	Circular	3000	C50	0.1	0.2	4527	471	253	28.2	1.46	1.45	1.55
3	Circular	3000	C50	0.2	0.1	4096	223	432	62.7	1.51	1.49	1.51
4	Circular	6000	C50	0.1	0.1	4318	341	370	47.3	1.49	1.47	1.54
5	Circular	6000	C50	0.1	0.2	3368	464	277	30.8	1.42	1.41	1.54
6	Circular	6000	C50	0.2	0.1	2990	221	437	63.2	1.49	1.45	1.47
7	Circular	3000	C90	0.1	0.1	8456	471	477	45.3	1.58	1.53	1.59
8	Circular	3000	C90	0.1	0.2	6153	642	343	28.1	1.45	1.43	1.59
9	Circular	3000	C90	0.2	0.1	5739	314	605	62.6	1.58	1.47	1.51
10	Circular	6000	C90	0.1	0.1	5962	475	501	46.5	1.53	1.46	1.56
11	Circular	6000	C90	0.1	0.2	4409	613	358	30.3	1.36	1.35	1.57
12	Circular	6000	C90	0.2	0.1	3980	299	582	62.8	1.54	1.40	1.43
13	Square	3000	C50	0.1	0.1	6426	321	330	45.8	1.49	1.42	1.52
14	Square	3000	C50	0.1	0.2	4972	459	251	28.7	1.46	1.38	1.52
15	Square	3000	C50	0.2	0.1	4561	224	430	62.5	1.49	1.42	1.51
16	Square	6000	C50	0.1	0.1	4850	346	381	47.8	1.48	1.39	1.52
17	Square	6000	C50	0.1	0.2	3888	466	291	32.0	1.44	1.34	1.52
18	Square	6000	C50	0.2	0.1	3482	233	456	63.0	1.48	1.38	1.48
19	Square	3000	C90	0.1	0.1	8598	429	437	45.5	1.59	1.41	1.61
20	Square	3000	C90	0.1	0.2	6564	608	330	28.5	1.53	1.33	1.61
21	Square	3000	C90	0.2	0.1	6177	304	582	62.4	1.60	1.38	1.57
22	Square	6000	C90	0.1	0.1	6438	459	492	47.0	1.56	1.35	1.60
23	Square	6000	C90	0.1	0.2	4970	599	363	31.2	1.48	1.27	1.60
24	Square	6000	C90	0.2	0.1	4516	306	591	62.7	1.57	1.31	1.50

Figure 7.8. Study on Overall Safety Factor for Biaxial Bending in General Method of EC4

7.4. Conclusion

In this chapter, two problems are solved. Firstly, an alternative is proposed to the conservative combination of Eurocode 4 for biaxial bending resistance. Secondly, it was proven that, for biaxial case in general method of Eurocode 4, the designer can develop overall safety factor only for principal axes, take the smaller of them as the section overall safety factor for biaxial bending and still be on the safe side. This way, they do not have to calculate the biaxial interaction surface for the general method of Eurocode 4.

The presented solutions to the tedious design tasks that necessitate use of designated and commercial software, enables hand or spreadsheet calculations and therefore gives control to the engineer rather than to the software.

8. VERIFICATION OF THE PROPOSED METHOD

In Chapter 6, a new initial bow imperfection value (L/400) and a new effective flexural stiffness equation (Equation 6.11) were proposed to calculate second order internal moments for concrete encased steel columns of normal and high strength concrete. The proposed values are less conservative than the current Eurocode 4's specifications for concrete encased steel columns. It was shown in Chapter 6 with an extensive parametric study that the proposed method conservatively captures the resistances of 2888 columns with varying concrete classes, steel grades, slendernesses and load eccentricities. However, the parametric study was conducted with FE models where all the materials were modelled with their mean resistances. This was done mainly because effective flexural stiffness ($EI_{eff,II}$) in Eurocode 4 being free of material partial safety factors and stiffness contribution from concrete depending on the mean concrete secant modulus of elasticity and not the design value.

Conducting the parametric study with mean resistances and showing the method conservatively capturing the overall resistance is a positive step for the verification of the proposed method. However, since the aim of the proposal is that it will in the end be used for a design engineer and therefore with design resistances, the need arises to conduct a separate verification with design resistances. This chapter's aim is to finalize this verification.

The task of verification of the proposed design method on composite columns is not trivial. Failure happens on the cross section as a mixed effect of bending moment and normal force. Bending moment is related to the normal force by the initial bow imperfection, load eccentricity, flexural stiffness, deflection. It is not possible due to the interrelation between normal force and internal bending moment to propose a closed form analytical "resistance equation" and validate it against test resistances. The hypothetical resistance equation would be different for every level of normal force. Due to the interrelation between applied force and internal bending moment, column resistance checks are conducted using interaction curves or equations in any design standard. Therefore, interaction curves are also used here for the verification.

The previously presented nine slender concrete encased steel column tests [1] as described in Section 3.1 are used for the verification. To perform this, it is necessary to firstly obtain design resistances from the nominal resistances of the tests. As previously explained and applied in Section 7.3, general method of Eurocode 4 allows for calculating the overall safety factor for GMNIA analysis in which the nonlinear model is run by nominal material resistances and than the obtained nominal resistance is divided by the overal safety factor to obtain the design resistance. Although they are real tests and not FE analysis, overall safety factor will be calculated for the mentioned tests and the test resistance will be divided by it to obtain the design resistance to be used in verification. The tests had biaxial bending behaviour, therefore the proposals of Chapter 7 will also be applied for the tests. In other words, firstly the uniaxial bending moment at midspan for both major and minor axes will be calculated by Equation 6.11 and initial bow imperfection of L/400. Their biaxial bending moment resultant at midspan as well as the angle the resultant makes with the major axis will be calculated. For the found orientation, the design biaxial interaction curve will be calculated with previously written Python software. Then, the proximity of the design point to the design biaxial interaction curve will be checked. If the points lie inside of the buckling curve, the proposed method is nonconservative and if they lie outside, proposed method is conservative in calculating column resistances. The explained procedure is outlined in Figures 8.1 to 8.3.

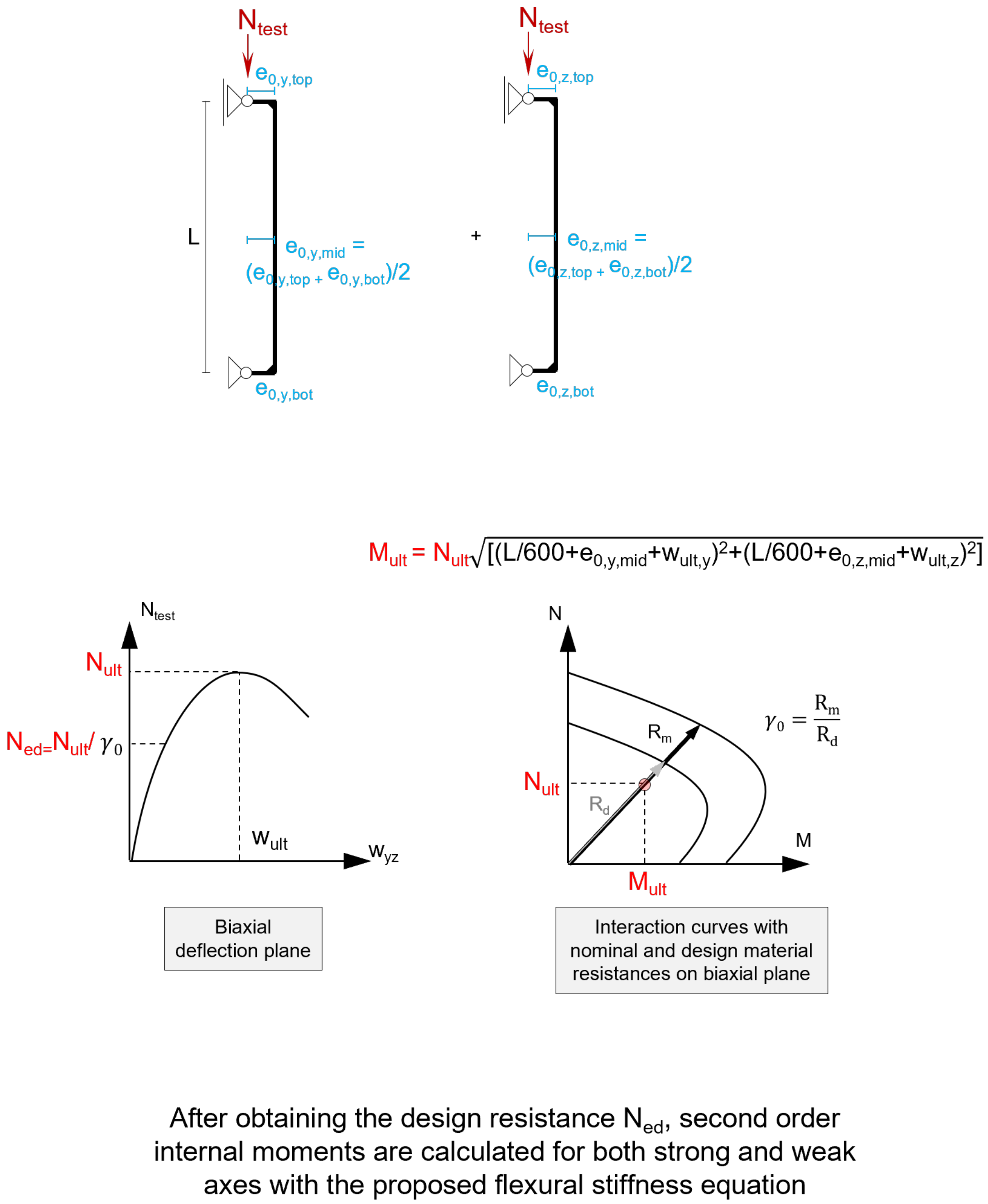


Figure 8.1. Verification Methodology

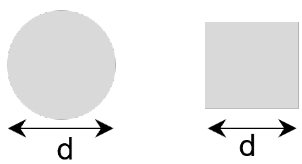
$$M_{Ed} = \frac{M_{Ed,Im} + \beta_M M_{Ed,Em}}{1 - \frac{N_{Ed}}{N_{cr}}} = \frac{N_{Ed}(\frac{L}{400} + e_{0,mid}) + \beta_M N_{Ed}[\max(e_{0,top}, e_{0,bot})]}{1 - \frac{N_{Ed}}{N_{cr}}}$$

$$N_{cr} = \frac{\pi^2 EI_{eff,II,prop}}{L^2} \qquad EI_{eff,II,prop} = 0.9(E_a I_a + E_s I_s + C E_{c,eff} I_c)$$

C

		e_0/d		
		0	0.1	0.2
f_{ck}	C30	0.8	0.5	0.2
	C90	1	0.8	0.6

$$C = \left[0.8 - 3\left(\frac{e_{0,mid}}{d}\right)\right] + \left(\frac{f_{ck} - 30}{60}\right)\left(0.2 + \left(\frac{e_{0,mid}}{d}\right)\right)$$



$M_{Ed,y}$ and $M_{Ed,z}$ are obtained with proposed equation above. Angle α is obtained from them and the biaxial interaction curve is created.

Figure 8.2. Verification Methodology Continued

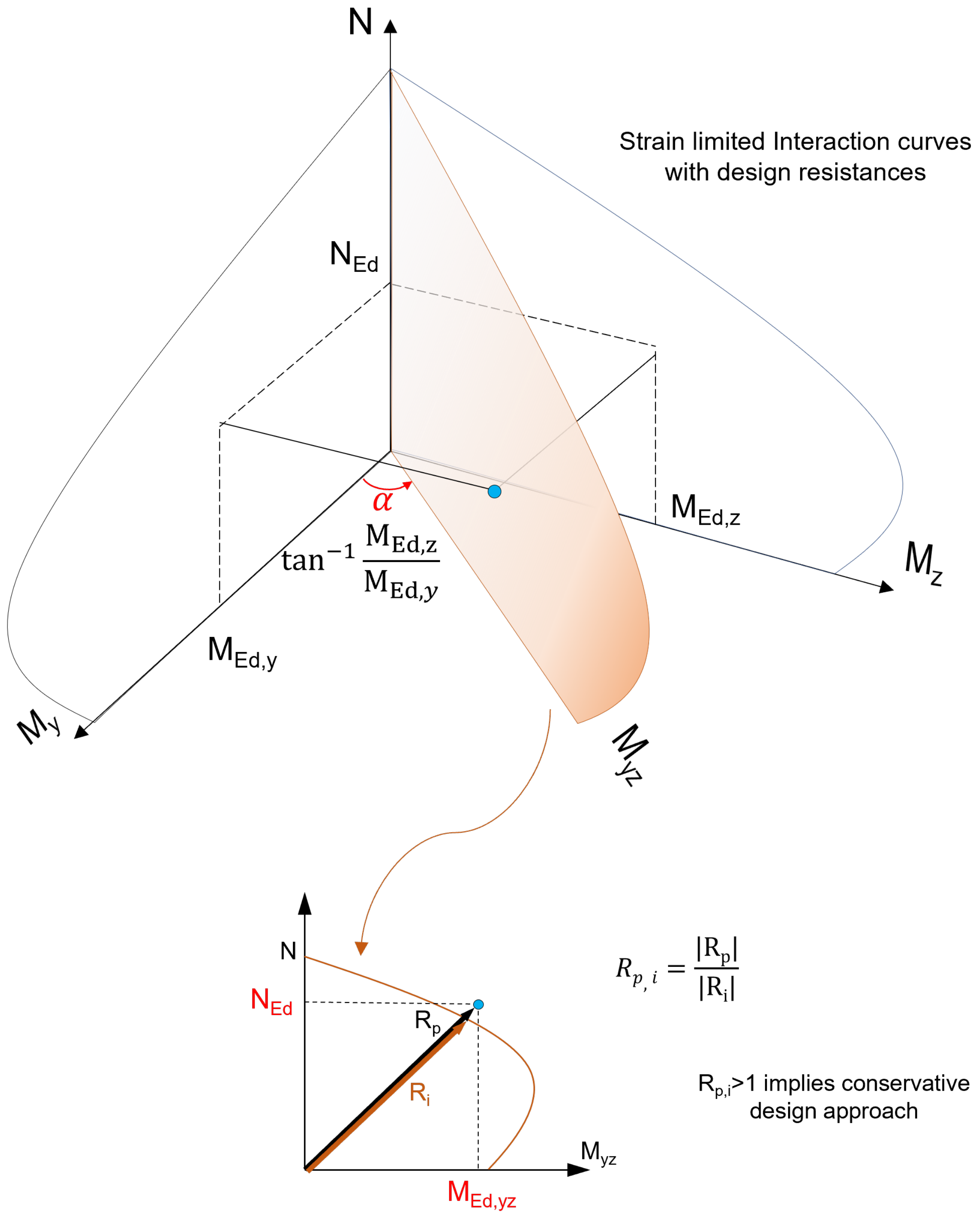


Figure 8.3. Verification Methodology Continued

The above explained verification methodology was applied to the nine column tests [1] and 12 of the columns from the literature listed previously in Table 3.3. The found $R_{p,i}$ values are presented in Table 8.1. Values greater than 1 concludes that the proposed method is on the safe side on the design level. All of the shown values fulfill the safety criteria.

Table 8.1. Verification Results

Specimen	Load Eccentricity	$R_{p,i}$
A1.1 (Circular) [1]	Eccentric	1.06
A1.2 (Circular) [1]	Eccentric	1.24
A1.3 (Circular) [1]	Eccentric	1.13
A1.4 (Circular) [1]	Eccentric	1.07
A1.5 (Circular) [1]	Eccentric	1.14
B1.1 (Square) [1]	Eccentric	1.03
B1.2 (Square) [1]	Eccentric	1.23
B1.3 (Square) [1]	Eccentric	2.14
B1.4 (Square) [1]	Eccentric	1.46
v11 (Square) [5]	Eccentric	1.24
v12 (Square) [5]	Eccentric	1.14
v21 (Square) [5]	Eccentric	1.27
v22 (Square) [5]	Eccentric	1.25
v31 (Square) [5]	Eccentric	1.13
v32 (Square) [5]	Eccentric	1.13
v41 (Square) [5]	Eccentric	1.11
v42 (Square) [5]	Eccentric	1.06
v43 (Square) [5]	Eccentric	1.02
v113 (Square) [5]	Centric	1.26
CES1 (Square) [6]	Centric	1.02
CES2 (Rectangular) [6]	Centric	1.2
CES3 (Rectangulae) [6]	Centric	1.4

9. CONCLUSION

In this dissertation, composite columns having concrete encased steel sections with different material properties were investigated. Tests from the literature including a recent extensive testing campaign with author taking part in development [1] are presented. Tests are modelled with complex finite element analysis models in Abaqus to successfully capture the behaviour in a simulation environment. The methodology presented herein for modelling buckling of concrete encased steel columns and their load introduction provides an accurate framework and starting point for further researchers working on this typology.

Using the large scale column tests [1], initial bow imperfection to be used in modelling was calibrated. The only varying factor for modelling 9 columns was the bow imperfection and average of the best fit to test resulted with L/660. L/600 is proposed to be used as initial geometric bow imperfection for concrete encased steel sections for nonlinear finite element analysis. Previously used value L/1000 for the general method of composite column design was adopted from steel structures but was not measured on composite columns. Lacking such a statistical data for the typology presented here, proposed imperfection bases itself on the calibration of FE analysis.

After succesfully modelling the large column tests, an extensive parametric study was designed. Therein, a matrix for input sections was created for HEB profiles with circular and square sections. Each column was modelled firstly with buckling analysis, then using the buckling shape as form of initial bow imperfection with explicit dynamic analysis. This was repeated for each column for two cases: with and without creep. No simplification from the complexity of calibration models was undertaken, which made the task of pre and postprocessing of 2880 Abaqus runs cumbersome. However, automating most of the process thanks to object oriented programming in Python and using the high performance computing cluster of University of Luxembourg [49], it was possible to obtain ultimate forces and deflections for each simulation run. The results are initially used with the purpose of fitting the sections to European buckling curves. Buckling curves are the present design method for normally loaded composite columns. Therefore, normally loaded parametric study runs were placed on the buckling curves. To do this, the design resistances had to be obtained first since parametric study included mean resistances. Methodology of general method of Eurocode 4 was adopted to achieve design resistances. Obtained design resistances with corresponding slenderness ratios for each normally loaded parametric study run was plotted on buckling curves. Effect of creep on simulation results was also included. Plots show that it is not possible to classify the sections to a buckling curve that would be in harmony over different slenderness values. Thanks to large number of inputs, the scatter was shown clearly. Reasons are explained in Chapter 6. Inability to classify columns on buckling curves led to the search for a new method to design encased sections.

The proposed method to design composite columns does not separate between normally and eccentrically loaded columns. It is foreseen that a strain limited interaction curve shall be used in design for both, and the resistance shall be calculated with a mixed vector of both axial force and internal moment. This is similar to the approach of general method which is used to find overall safety factor for arbitrary sections. Use of a radial vector allows for successfully capture of resistance not only for cases with high moment - tensile failure zone but also low moment - compressive failure zone on the interaction curve.

Conservative calculation of internal second order moments (moment amplification) without help of an advanced finite element analysis software is crucial for a simplified design method. Current Eurocode 4 requires use of $EI_{eff,II}$ as the flexural stiffness value to be used in calculation of second order internal moments. This value was tested for each parametric study run. In other words, the obtained ultimate force from parametric run was used to calculate internal second order moment using $EI_{eff,II}$ with a bow imperfection of L/600, the accuracy of ultimate force - calculated internal second order moment pair was assessed by its vectoral proximity to the interaction curve along same radial direction. Results confirmed resistances of most of the points to be on the safe side for parametric study runs using the methodology, but not all of them. Modification was deemed necessary for two reasons; firstly because for many normally loaded columns, critical buckling load was exceeded by ultimate resistance from the FEA. This indicates the second order flexural stiffness of current Eurocode 4 to be underestimated for normally loaded columns. In other words, Eurocode 4 assumes larger cracking for those columns that what parametric study indicated. Second reason for modification was that although most of the points were on the safe side on Figure 6.15, there are still points with vertical axis value less than 1. To cover all of the parametric study inputs safely, a modification is proposed on second order flexural stiffness for calculating internal bending moments. Proposed approach replaces the initial equivalent bow imperfection definitions from current Eurocode 4 for encased sections which are L/200 and L/150 depending on bending axis. These values stem from their corresponding buckling curve classification. They were calculated historically to ensure the second order moment calculated by moment amplification equation results with the same moment value from interaction curve corresponding to the reduced force from buckling curve. New approach removes the dependency on buckling curves and proposes L/600 to be used on geometrically and materially nonlinear FEA analysis. For calculating internal bending moments, L/400 is proposed as the equivalent bow imperfection to be used with proposed flexural stiffness in Equation 6.11 and in Figure 6.18 to replace $EI_{eff,II}$ of Eurocode 4. This combination of flexural stiffness and bow imperfection is shown to conservatively capture resistance of all parametric study runs in Figure 6.20.

Strain limited approach to create interaction curves was chosen over fully plastic approach since the encased sections were observed to reach ultimate force when concrete crushes rather than when steel profile fails. Since current Eurocode 4 requires the use of fully plastic section and it is the state of the art, a modification to the fully plastic section approach is proposed to give the designer the option to design with fully plastic interaction curves. For this, α_M of Eurocode 4 is replaced with α_{MN}. The parametric study sections are used to calibrate the values depending on steel grade and concrete strength class.

Biaxial bending was found to be present in the test specimens and contributed to the failure although it wasn't intended. A software was developed which able to create strain limited biaxial interaction surfaces for different bending angles over the section. The software was firstly used to show the effect of biaxial bending on failure of test specimens. During the investigation, it was found that circular sections have a large residual capacity under biaxial bending. To utilize it, a new equation is proposed to calculate interaction curves of arbitrary bending angles over the section when the major and minor axes interaction curve data points are known. Proposed equation was calibrated against the sections of parametric study.

Presented testing campaign, FE models, extensive parametric study and the design method lays foundation of a new approach to design concrete encased steel composite columns having normal and high strength steel and concrete. Greatest benefit of the new method is the better utilization of material strengths and thus increasing the efficiency of the engineering for the typology presented.

The proposed method is summarized in flowcharts for different cases in Figures

9.1 to 9.3

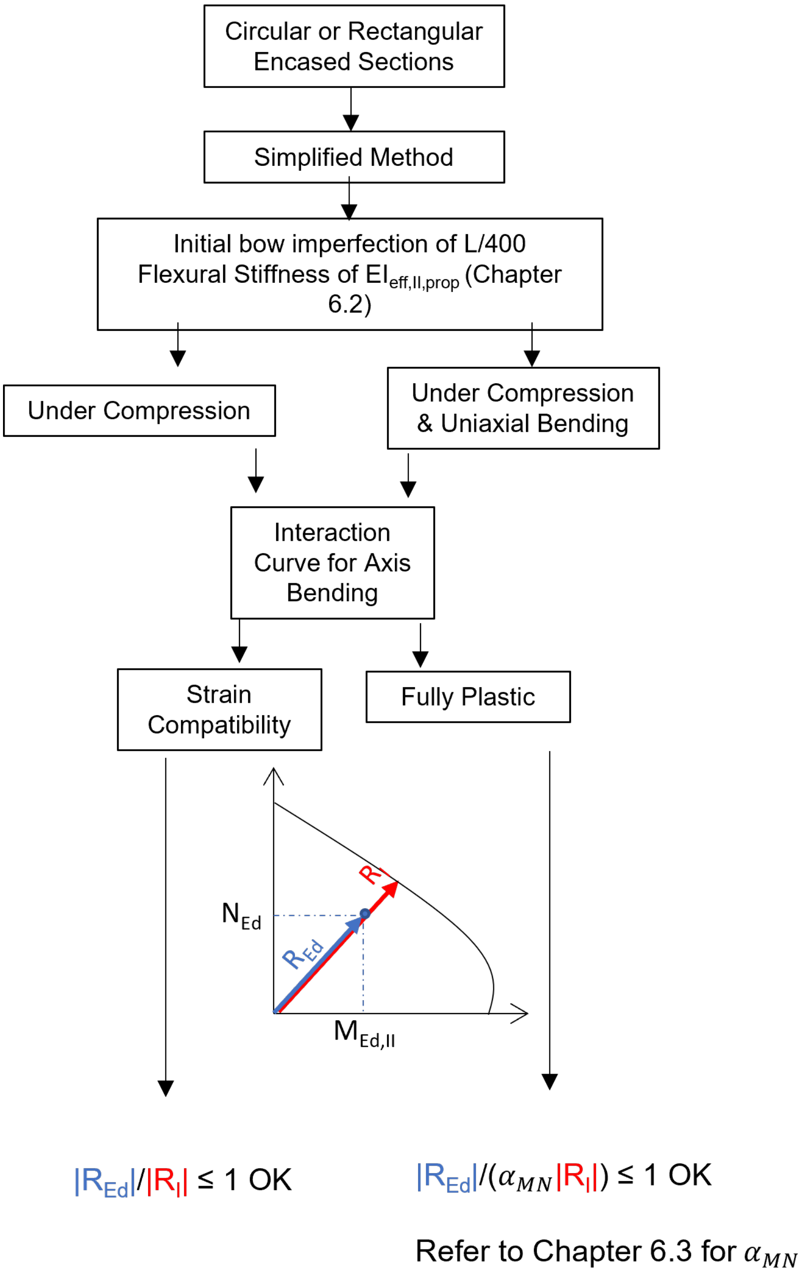


Figure 9.1. Design Flowchart for Proposed Changes in Simplified Method for Pure Compression and Compression with Uniaxial Bending

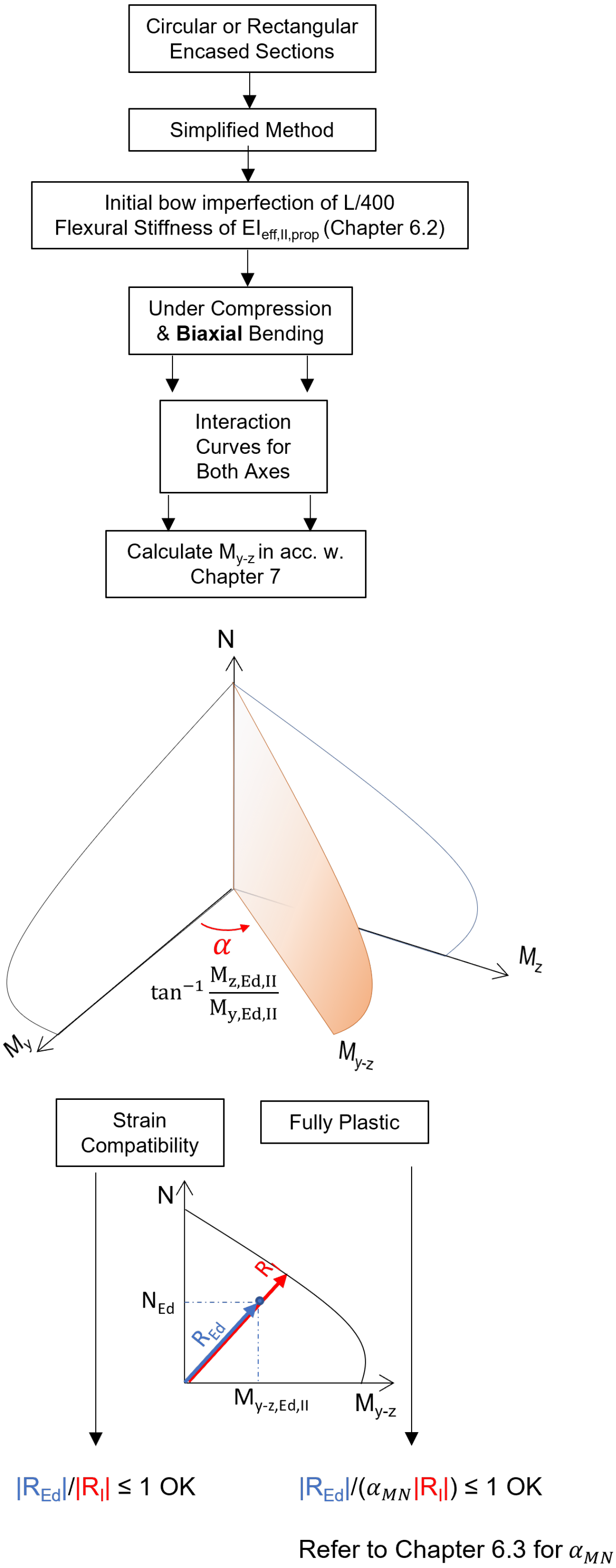


Figure 9.2. Design Flowchart for Proposed Changes in Simplified Method for Compression with Biaxial Bending

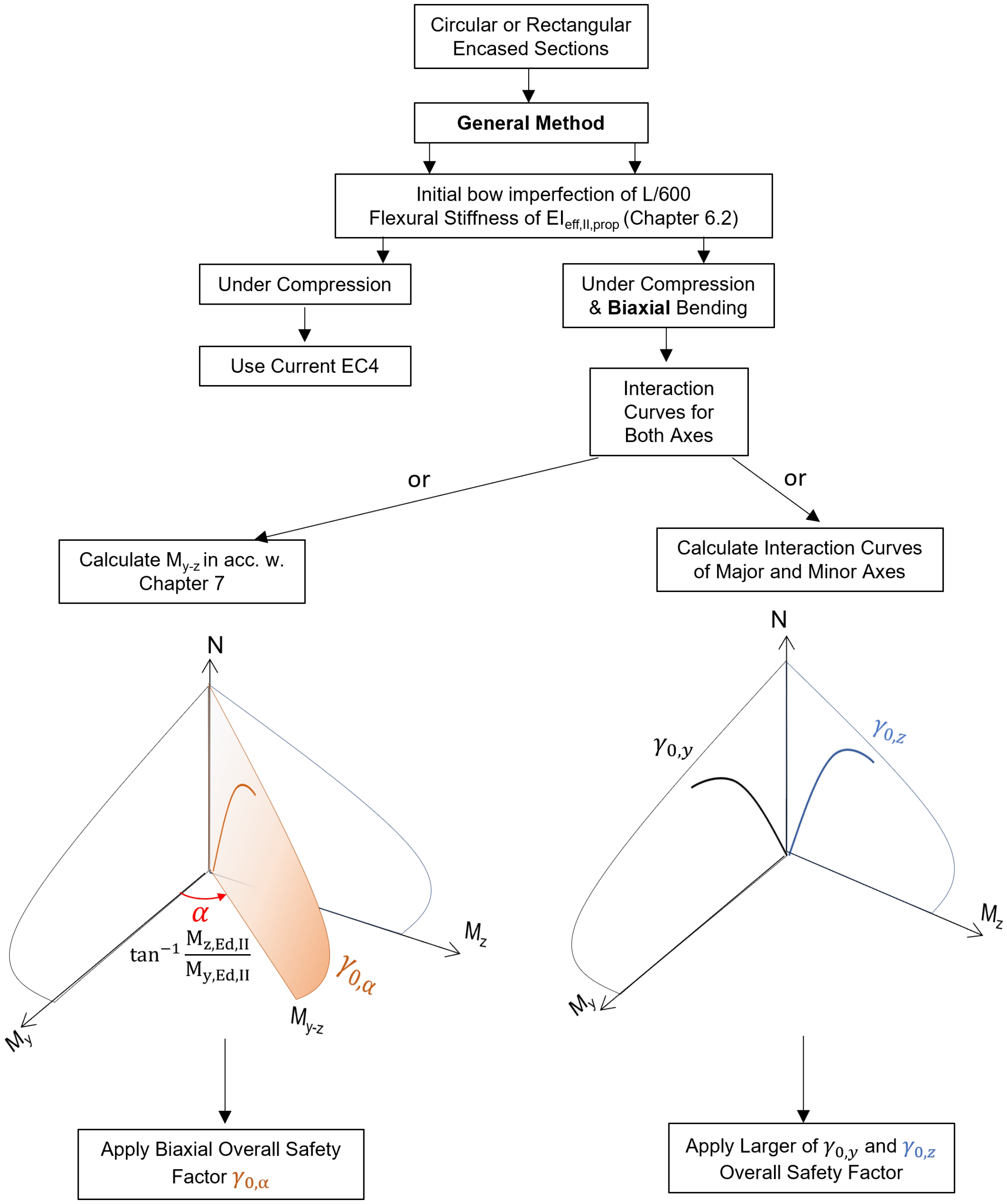


Figure 9.3. Design Flowchart for Proposed Changes in General Method for Compression with Biaxial Bending

9.1. Outlook

In this dissertation, the focus was on global behaviour of concrete encased steel columns under normal and eccentric loading. Tests were taken as basis to develop a high fidelity FE model which was also flexible enough to enable an extensive parametric study. Since the tests found in literature had end plates on column specimens, differential deformation between steel profile and concrete was never an issue, therefore also was not considered in constraint modelling in FEA. Use of end plates in testing of concrete encased steel columns is preferred almost always because of safety, test setup availability and production reasons. On the other hand, in a real world structure where concrete encased steel sections are utilized in floors of a building, the load introduction from the slab might not always be same or similar to that through an end plate. Local effects of load introduction, constructive detailing, sequence of construction can play a crucial load on fully utilization of global buckling resistance of concrete encased steel columns. It inevitable to note that, the design method presented here can be used to calculate resistance only when the safe load transfer from the slab to the column is allowed for.

For the scope of this work, columns are only considered as isolated elements. Possible stiffness contribution from upper and lower slabs and floors are not considered on the behaviour of the columns. These effects can be beneficial or detrimental depending on the actual load cases and stiffness differences between adjacent floors and slabs. An investigation on effects of adjacent structures to the resistance of encased columns can further extend the scope of this research.

Since global resistance and behaviour was the main topic in this work, local effects are not deeply investigated. Local effects that effect the behaviour include but are not limited to spalling, reinforcement buckling, horizontal stress distribution at column section, differential strains on the column section, confinement effects, crack propagation, creep and shrinkage. A more localized FE modelling approach with very small finite elements paired with tests focusing on local strains on the section for columns would be enlightening for the local effects on the column section which might initiate the global failure as well.

Another interesting research would be to focus on deflection limits on slender encased columns. It was experienced in the parametric study that slender columns can undergo very large deflections and reading only maximum force as the limit state can be misleading since deflections may become very large long before reaching maximum force resistance.

APPENDIX A: Data from The Parametric Study for Column Resistances

In Table A.1, all of the column capacities as well as deflections at ultimate forces with the γ_0 values for each of them from general method of Eurocode 4 are listed. First half of the table rows are simulations without creep and second are with creep. Simulations were run using mean resistances. Keys to the letters are listed below.

- C: Circular
- S: Square
- D: Diameter of circular sections and edge length of square sections.

All lengths are given in mm, forces in N and stresses in MPa.

Table A.1: Input and Outputs of Parametric Study for Column Resistances

Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1	0	3000	Major	C	450	heb220	30	355	500	8 d14	No	9244230	2.3	1.50
2	0	3000	Major	C	450	heb220	30	355	700	8 d25	No	10440596	2.1	1.36
3	0	3000	Minor	C	450	heb220	30	355	500	8 d14	No	8916878	2.7	1.50
4	0	3000	Minor	C	450	heb220	30	355	700	8 d25	No	10253090	2.6	1.36
5	0	3000	Major	C	450	heb220	30	460	500	8 d14	No	9748253	1.9	1.47
6	0	3000	Major	C	450	heb220	30	460	700	8 d25	No	11754111	3.5	1.36
7	0	3000	Minor	C	450	heb220	30	460	500	8 d14	No	9321927	2.4	1.47
8	0	3000	Minor	C	450	heb220	30	460	700	8 d25	No	11351384	4.2	1.35
9	0	3000	Major	C	450	heb220	30	550	500	8 d14	No	10234430	2.6	1.40
10	0	3000	Major	C	450	heb220	30	550	700	8 d25	No	12150901	4.0	1.31
11	0	3000	Minor	C	450	heb220	30	550	500	8 d14	No	9795249	3.6	1.41
12	0	3000	Minor	C	450	heb220	30	550	700	8 d25	No	11593066	4.5	1.31
13	0	3000	Major	C	450	heb220	60	355	500	8 d14	No	13311127	2.4	1.75
14	0	3000	Major	C	450	heb220	60	355	700	8 d25	No	14702384	2.3	1.55
15	0	3000	Minor	C	450	heb220	60	355	500	8 d14	No	13295927	2.9	1.75
16	0	3000	Minor	C	450	heb220	60	355	700	8 d25	No	14704852	2.6	1.55
17	0	3000	Major	C	450	heb220	60	460	500	8 d14	No	14157906	2.1	1.71
18	0	3000	Major	C	450	heb220	60	460	700	8 d25	No	15625904	2.1	1.53
19	0	3000	Minor	C	450	heb220	60	460	500	8 d14	No	13826494	2.6	1.69
20	0	3000	Minor	C	450	heb220	60	460	700	8 d25	No	15309530	2.4	1.52
21	0	3000	Major	C	450	heb220	60	550	500	8 d14	No	14439755	2.2	1.61
22	0	3000	Major	C	450	heb220	60	550	700	8 d25	No	15988136	2.1	1.46
23	0	3000	Minor	C	450	heb220	60	550	500	8 d14	No	14146882	2.8	1.58
24	0	3000	Minor	C	450	heb220	60	550	700	8 d25	No	15662211	2.5	1.44
25	0	3000	Major	C	450	heb220	90	355	500	8 d14	No	17303310	2.0	1.88
26	0	3000	Major	C	450	heb220	90	355	700	8 d25	No	18819134	2.1	1.66
27	0	3000	Minor	C	450	heb220	90	355	500	8 d14	No	17296154	2.2	1.88
28	0	3000	Minor	C	450	heb220	90	355	700	8 d25	No	18796524	2.3	1.66
29	0	3000	Major	C	450	heb220	90	460	500	8 d14	No	18385608	2.1	1.83

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Table A.1 – continued from previous page

Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
30	0	3000	Major	C	450	heb220	90	460	700	8 d25	No	19661104	1.9	1.64
31	0	3000	Minor	C	450	heb220	90	460	500	8 d14	No	18024978	2.2	1.81
32	0	3000	Minor	C	450	heb220	90	460	700	8 d25	No	19601974	2.4	1.62
33	0	3000	Major	C	450	heb220	90	550	500	8 d14	No	18523876	1.9	1.72
34	0	3000	Major	C	450	heb220	90	550	700	8 d25	No	19791548	1.7	1.56
35	0	3000	Minor	C	450	heb220	90	550	500	8 d14	No	18123898	2.0	1.71
36	0	3000	Minor	C	450	heb220	90	550	700	8 d25	No	19750248	2.1	1.54
37	0	6000	Major	C	450	heb220	30	355	500	8 d14	No	7711901	16.0	1.49
38	0	6000	Major	C	450	heb220	30	355	700	8 d25	No	8752522	16.4	1.37
39	0	6000	Minor	C	450	heb220	30	355	500	8 d14	No	7339498	23.8	1.48
40	0	6000	Minor	C	450	heb220	30	355	700	8 d25	No	8461958	27.5	1.36
41	0	6000	Major	C	450	heb220	30	460	500	8 d14	No	8270735.5	23.2	1.46
42	0	6000	Major	C	450	heb220	30	460	700	8 d25	No	9582275	25.6	1.36
43	0	6000	Minor	C	450	heb220	30	460	500	8 d14	No	7471572.5	25.4	1.45
44	0	6000	Minor	C	450	heb220	30	460	700	8 d25	No	8709624	28.1	1.34
45	0	6000	Major	C	450	heb220	30	550	500	8 d14	No	8284242	23.2	1.37
46	0	6000	Major	C	450	heb220	30	550	700	8 d25	No	9621018	25.5	1.30
47	0	6000	Minor	C	450	heb220	30	550	500	8 d14	No	7474068	25.4	1.44
48	0	6000	Minor	C	450	heb220	30	550	700	8 d25	No	8723847	28.1	1.32
49	0	6000	Major	C	450	heb220	60	355	500	8 d14	No	11004544	19.5	1.56
50	0	6000	Major	C	450	heb220	60	355	700	8 d25	No	12114344	18.7	1.44
51	0	6000	Minor	C	450	heb220	60	355	500	8 d14	No	10405228	21.0	1.55
52	0	6000	Minor	C	450	heb220	60	355	700	8 d25	No	11616610	21.4	1.42
53	0	6000	Major	C	450	heb220	60	460	500	8 d14	No	11411837	18.7	1.52
54	0	6000	Major	C	450	heb220	60	460	700	8 d25	No	12557854	17.8	1.41
55	0	6000	Minor	C	450	heb220	60	460	500	8 d14	No	10685175	21.3	1.50
56	0	6000	Minor	C	450	heb220	60	460	700	8 d25	No	11839000	19.7	1.39
57	0	6000	Major	C	450	heb220	60	550	500	8 d14	No	11416965	18.7	1.43
58	0	6000	Major	C	450	heb220	60	550	700	8 d25	No	12563525	17.7	1.34
59	0	6000	Minor	C	450	heb220	60	550	500	8 d14	No	10683928	21.3	1.49
60	0	6000	Minor	C	450	heb220	60	550	700	8 d25	No	11839431	19.7	1.37
61	0	6000	Major	C	450	heb220	90	355	500	8 d14	No	14209400	17.1	1.65
62	0	6000	Major	C	450	heb220	90	355	700	8 d25	No	14936126	17.3	1.52
63	0	6000	Minor	C	450	heb220	90	355	500	8 d14	No	12727232	17.9	1.64
64	0	6000	Minor	C	450	heb220	90	355	700	8 d25	No	14168969	17.4	1.50
65	0	6000	Major	C	450	heb220	90	460	500	8 d14	No	14936931	17.2	1.59
66	0	6000	Major	C	450	heb220	90	460	700	8 d25	No	15623871	15.4	1.48
67	0	6000	Minor	C	450	heb220	90	460	500	8 d14	No	13322534	19.1	1.58
68	0	6000	Minor	C	450	heb220	90	460	700	8 d25	No	14827294	18.3	1.45
69	0	6000	Major	C	450	heb220	90	550	500	8 d14	No	14953928	17.1	1.51
70	0	6000	Major	C	450	heb220	90	550	700	8 d25	No	15631477	15.4	1.41
71	0	6000	Minor	C	450	heb220	90	550	500	8 d14	No	13323513	19.1	1.56
72	0	6000	Minor	C	450	heb220	90	550	700	8 d25	No	14834741	18.3	1.43
73	0	8000	Major	C	450	heb220	30	355	500	8 d14	No	6556823.5	45.2	1.47
74	0	8000	Major	C	450	heb220	30	355	700	8 d25	No	7447306	45.3	1.36
75	0	8000	Minor	C	450	heb220	30	355	500	8 d14	No	5874073	48.6	1.50
76	0	8000	Minor	C	450	heb220	30	355	700	8 d25	No	6769487	50.2	1.36
77	0	8000	Major	C	450	heb220	30	460	500	8 d14	No	6633915	47.8	1.42
78	0	8000	Major	C	450	heb220	30	460	700	8 d25	No	7548205	47.6	1.33
79	0	8000	Minor	C	450	heb220	30	460	500	8 d14	No	5907540.5	48.4	1.48
80	0	8000	Minor	C	450	heb220	30	460	700	8 d25	No	6817633.5	49.9	1.34
81	0	8000	Major	C	450	heb220	30	550	500	8 d14	No	6633915	47.8	1.37
82	0	8000	Major	C	450	heb220	30	550	700	8 d25	No	7548205	47.6	1.28
83	0	8000	Minor	C	450	heb220	30	550	500	8 d14	No	5907540.5	48.4	1.48

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Table A.1 – continued from previous page

Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
84	0	8000	Minor	C	450	heb220	30	550	700	8 d25	No	6817633.5	49.9	1.33
85	0	8000	Major	C	450	heb220	60	355	500	8 d14	No	8810073	42.9	1.52
86	0	8000	Major	C	450	heb220	60	355	700	8 d25	No	9684652	45.5	1.39
87	0	8000	Minor	C	450	heb220	60	355	500	8 d14	No	8154717	46.7	1.54
88	0	8000	Minor	C	450	heb220	60	355	700	8 d25	No	9055365	48.9	1.39
89	0	8000	Major	C	450	heb220	60	460	500	8 d14	No	8930000	45.2	1.44
90	0	8000	Major	C	450	heb220	60	460	700	8 d25	No	9814218	44.5	1.34
91	0	8000	Minor	C	450	heb220	60	460	500	8 d14	No	8206313	46.3	1.50
92	0	8000	Minor	C	450	heb220	60	460	700	8 d25	No	9132006	48.0	1.35
93	0	8000	Major	C	450	heb220	60	550	500	8 d14	No	8930000	45.2	1.40
94	0	8000	Major	C	450	heb220	60	550	700	8 d25	No	9814218	44.5	1.30
95	0	8000	Minor	C	450	heb220	60	550	500	8 d14	No	8206313	46.3	1.50
96	0	8000	Minor	C	450	heb220	60	550	700	8 d25	No	9132006	48.0	1.35
97	0	8000	Major	C	450	heb220	90	355	500	8 d14	No	11211042	44.3	1.57
98	0	8000	Major	C	450	heb220	90	355	700	8 d25	No	11709796	41.1	1.45
99	0	8000	Minor	C	450	heb220	90	355	500	8 d14	No	9869915	42.7	1.58
100	0	8000	Minor	C	450	heb220	90	355	700	8 d25	No	10896931	44.1	1.43
101	0	8000	Major	C	450	heb220	90	460	500	8 d14	No	11377024	42.9	1.48
102	0	8000	Major	C	450	heb220	90	460	700	8 d25	No	11987499	42.2	1.37
103	0	8000	Minor	C	450	heb220	90	460	500	8 d14	No	9943282	42.3	1.54
104	0	8000	Minor	C	450	heb220	90	460	700	8 d25	No	10983726	43.4	1.39
105	0	8000	Major	C	450	heb220	90	550	500	8 d14	No	11377024	42.9	1.44
106	0	8000	Major	C	450	heb220	90	550	700	8 d25	No	11987499	42.2	1.33
107	0	8000	Minor	C	450	heb220	90	550	500	8 d14	No	9943282	42.3	1.54
108	0	8000	Minor	C	450	heb220	90	550	700	8 d25	No	10983726	43.4	1.39
109	0	10000	Major	C	450	heb220	30	355	500	8 d14	No	5178802	64.2	1.44
110	0	10000	Major	C	450	heb220	30	355	700	8 d25	No	5801054	67.0	1.34
111	0	10000	Minor	C	450	heb220	30	355	500	8 d14	No	4761238.5	64.4	1.49
112	0	10000	Minor	C	450	heb220	30	355	700	8 d25	No	5345788	67.2	1.34
113	0	10000	Major	C	450	heb220	30	460	500	8 d14	No	5184755	68.0	1.37
114	0	10000	Major	C	450	heb220	30	460	700	8 d25	No	5809784	70.8	1.29
115	0	10000	Minor	C	450	heb220	30	460	500	8 d14	No	4761354	64.4	1.47
116	0	10000	Minor	C	450	heb220	30	460	700	8 d25	No	5346926	67.2	1.33
117	0	10000	Major	C	450	heb220	30	550	500	8 d14	No	5184755	68.0	1.36
118	0	10000	Major	C	450	heb220	30	550	700	8 d25	No	5809784	70.8	1.28
119	0	10000	Minor	C	450	heb220	30	550	500	8 d14	No	4761354	64.4	1.47
120	0	10000	Minor	C	450	heb220	30	550	700	8 d25	No	5346926	67.2	1.33
121	0	10000	Major	C	450	heb220	60	355	500	8 d14	No	6608975.5	73.8	1.46
122	0	10000	Major	C	450	heb220	60	355	700	8 d25	No	7250903	73.1	1.35
123	0	10000	Minor	C	450	heb220	60	355	500	8 d14	No	6020814	74.6	1.50
124	0	10000	Minor	C	450	heb220	60	355	700	8 d25	No	6694287	72.6	1.35
125	0	10000	Major	C	450	heb220	60	460	500	8 d14	No	6622221	73.8	1.37
126	0	10000	Major	C	450	heb220	60	460	700	8 d25	No	7267317	73.0	1.28
127	0	10000	Minor	C	450	heb220	60	460	500	8 d14	No	6025834	74.6	1.48
128	0	10000	Minor	C	450	heb220	60	460	700	8 d25	No	6700235.5	72.5	1.33
129	0	10000	Major	C	450	heb220	60	550	500	8 d14	No	6622221	73.8	1.37
130	0	10000	Major	C	450	heb220	60	550	700	8 d25	No	7267317	73.0	1.27
131	0	10000	Minor	C	450	heb220	60	550	500	8 d14	No	6025834	74.6	1.48
132	0	10000	Minor	C	450	heb220	60	550	700	8 d25	No	6700235.5	72.5	1.33
133	0	10000	Major	C	450	heb220	90	355	500	8 d14	No	8259287	72.5	1.50
134	0	10000	Major	C	450	heb220	90	355	700	8 d25	No	8713526	76.4	1.37
135	0	10000	Minor	C	450	heb220	90	355	500	8 d14	No	7447986	74.7	1.53
136	0	10000	Minor	C	450	heb220	90	355	700	8 d25	No	8102531	79.2	1.36
137	0	10000	Major	C	450	heb220	90	460	500	8 d14	No	8287964	77.1	1.39

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Table A.1 – continued from previous page

Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
138	0	10000	Major	C	450	heb220	90	460	700	8 d25	No	8745504	81.0	1.28
139	0	10000	Minor	C	450	heb220	90	460	500	8 d14	No	7460528	80.2	1.51
140	0	10000	Minor	C	450	heb220	90	460	700	8 d25	No	8117152.5	79.1	1.35
141	0	10000	Major	C	450	heb220	90	550	500	8 d14	No	8287964	77.1	1.39
142	0	10000	Major	C	450	heb220	90	550	700	8 d25	No	8745504	81.0	1.28
143	0	10000	Minor	C	450	heb220	90	550	500	8 d14	No	7460528	80.2	1.51
144	0	10000	Minor	C	450	heb220	90	550	700	8 d25	No	8117152.5	79.1	1.35
145	0	3000	Major	S	400	heb260	30	355	500	8 d14	No	10257789	2.1	1.44
146	0	3000	Major	S	400	heb260	30	355	700	8 d25	No	11473115	2.0	1.33
147	0	3000	Minor	S	400	heb260	30	355	500	8 d14	No	9883469	3.0	1.44
148	0	3000	Minor	S	400	heb260	30	355	700	8 d25	No	11262627	2.8	1.33
149	0	3000	Major	S	400	heb260	30	460	500	8 d14	No	10945598	1.5	1.42
150	0	3000	Major	S	400	heb260	30	460	700	8 d25	No	13132742	3.5	1.33
151	0	3000	Minor	S	400	heb260	30	460	500	8 d14	No	10619390	2.6	1.42
152	0	3000	Minor	S	400	heb260	30	460	700	8 d25	No	12547725	4.5	1.32
153	0	3000	Major	S	400	heb260	30	550	500	8 d14	No	11568754	1.9	1.36
154	0	3000	Major	S	400	heb260	30	550	700	8 d25	No	13718081	3.4	1.29
155	0	3000	Minor	S	400	heb260	30	550	500	8 d14	No	11049057	3.2	1.36
156	0	3000	Minor	S	400	heb260	30	550	700	8 d25	No	12915125	4.3	1.28
157	0	3000	Major	S	400	heb260	60	355	500	8 d14	No	14330445	2.5	1.69
158	0	3000	Major	S	400	heb260	60	355	700	8 d25	No	15705799	2.5	1.51
159	0	3000	Minor	S	400	heb260	60	355	500	8 d14	No	14187449	2.8	1.69
160	0	3000	Minor	S	400	heb260	60	355	700	8 d25	No	15741900	2.8	1.51
161	0	3000	Major	S	400	heb260	60	460	500	8 d14	No	15691904	2.2	1.64
162	0	3000	Major	S	400	heb260	60	460	700	8 d25	No	17205374	2.1	1.49
163	0	3000	Minor	S	400	heb260	60	460	500	8 d14	No	15145883	2.7	1.63
164	0	3000	Minor	S	400	heb260	60	460	700	8 d25	No	16631727	2.5	1.48
165	0	3000	Major	S	400	heb260	60	550	500	8 d14	No	15901254	1.8	1.56
166	0	3000	Major	S	400	heb260	60	550	700	8 d25	No	17461234	1.8	1.44
167	0	3000	Minor	S	400	heb260	60	550	500	8 d14	No	15516537	2.6	1.53
168	0	3000	Minor	S	400	heb260	60	550	700	8 d25	No	17066380	2.5	1.41
169	0	3000	Major	S	400	heb260	90	355	500	8 d14	No	18388524	2.3	1.82
170	0	3000	Major	S	400	heb260	90	355	700	8 d25	No	19668842	2.0	1.63
171	0	3000	Minor	S	400	heb260	90	355	500	8 d14	No	18153028	2.2	1.83
172	0	3000	Minor	S	400	heb260	90	355	700	8 d25	No	19665738	2.2	1.63
173	0	3000	Major	S	400	heb260	90	460	500	8 d14	No	19784860	2.0	1.77
174	0	3000	Major	S	400	heb260	90	460	700	8 d25	No	21085148	1.8	1.61
175	0	3000	Minor	S	400	heb260	90	460	500	8 d14	No	19393572	2.4	1.76
176	0	3000	Minor	S	400	heb260	90	460	700	8 d25	No	20677590	2.2	1.59
177	0	3000	Major	S	400	heb260	90	550	500	8 d14	No	19998312	1.7	1.66
178	0	3000	Major	S	400	heb260	90	550	700	8 d25	No	21651130	1.8	1.52
179	0	3000	Minor	S	400	heb260	90	550	500	8 d14	No	19578148	2.1	1.64
180	0	3000	Minor	S	400	heb260	90	550	700	8 d25	No	21241900	2.2	1.50
181	0	6000	Major	S	400	heb260	30	355	500	8 d14	No	8835078	14.9	1.44
182	0	6000	Major	S	400	heb260	30	355	700	8 d25	No	9940337	15.2	1.34
183	0	6000	Minor	S	400	heb260	30	355	500	8 d14	No	8133775	23.7	1.44
184	0	6000	Minor	S	400	heb260	30	355	700	8 d25	No	9337736	24.6	1.34
185	0	6000	Major	S	400	heb260	30	460	500	8 d14	No	9702548	18.3	1.42
186	0	6000	Major	S	400	heb260	30	460	700	8 d25	No	11104690	23.2	1.34
187	0	6000	Minor	S	400	heb260	30	460	500	8 d14	No	8396468	24.0	1.41
188	0	6000	Minor	S	400	heb260	30	460	700	8 d25	No	9805198	27.9	1.32
189	0	6000	Major	S	400	heb260	30	550	500	8 d14	No	9736206	18.2	1.36
190	0	6000	Major	S	400	heb260	30	550	700	8 d25	No	11271734	24.2	1.29
191	0	6000	Minor	S	400	heb260	30	550	500	8 d14	No	8415704	24.0	1.37

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
192	0	6000	Minor	S	400	heb260	30	550	700	8 d25	No	9858786	27.6	1.29
193	0	6000	Major	S	400	heb260	60	355	500	8 d14	No	12139534	17.8	1.55
194	0	6000	Major	S	400	heb260	60	355	700	8 d25	No	13369648	18.6	1.43
195	0	6000	Minor	S	400	heb260	60	355	500	8 d14	No	11355971	23.1	1.54
196	0	6000	Minor	S	400	heb260	60	355	700	8 d25	No	12521835	21.1	1.42
197	0	6000	Major	S	400	heb260	60	460	500	8 d14	No	13046748	17.4	1.53
198	0	6000	Major	S	400	heb260	60	460	700	8 d25	No	14263071	16.6	1.43
199	0	6000	Minor	S	400	heb260	60	460	500	8 d14	No	11838196	21.5	1.50
200	0	6000	Minor	S	400	heb260	60	460	700	8 d25	No	13125886	21.7	1.39
201	0	6000	Major	S	400	heb260	60	550	500	8 d14	No	13083637	17.2	1.43
202	0	6000	Major	S	400	heb260	60	550	700	8 d25	No	14458191	17.5	1.35
203	0	6000	Minor	S	400	heb260	60	550	500	8 d14	No	11855957	21.4	1.45
204	0	6000	Minor	S	400	heb260	60	550	700	8 d25	No	13163502	21.4	1.34
205	0	6000	Major	S	400	heb260	90	355	500	8 d14	No	15519212	18.2	1.65
206	0	6000	Major	S	400	heb260	90	355	700	8 d25	No	16687791	18.3	1.52
207	0	6000	Minor	S	400	heb260	90	355	500	8 d14	No	14767982	20.4	1.64
208	0	6000	Minor	S	400	heb260	90	355	700	8 d25	No	15999580	19.7	1.51
209	0	6000	Major	S	400	heb260	90	460	500	8 d14	No	16568598	16.0	1.61
210	0	6000	Major	S	400	heb260	90	460	700	8 d25	No	17858456	16.0	1.50
211	0	6000	Minor	S	400	heb260	90	460	500	8 d14	No	15376484	19.0	1.58
212	0	6000	Minor	S	400	heb260	90	460	700	8 d25	No	16636022	18.4	1.46
213	0	6000	Major	S	400	heb260	90	550	500	8 d14	No	16629686	15.6	1.51
214	0	6000	Major	S	400	heb260	90	550	700	8 d25	No	17933044	15.5	1.41
215	0	6000	Minor	S	400	heb260	90	550	500	8 d14	No	15411656	18.8	1.53
216	0	6000	Minor	S	400	heb260	90	550	700	8 d25	No	16674328	18.2	1.42
217	0	8000	Major	S	400	heb260	30	355	500	8 d14	No	7414868.5	37.2	1.42
218	0	8000	Major	S	400	heb260	30	355	700	8 d25	No	8628994	39.5	1.33
219	0	8000	Minor	S	400	heb260	30	355	500	8 d14	No	6577468.5	46.4	1.46
220	0	8000	Minor	S	400	heb260	30	355	700	8 d25	No	7528622	44.6	1.34
221	0	8000	Major	S	400	heb260	30	460	500	8 d14	No	7931228.5	42.5	1.41
222	0	8000	Major	S	400	heb260	30	460	700	8 d25	No	8900948	46.0	1.33
223	0	8000	Minor	S	400	heb260	30	460	500	8 d14	No	6659083	49.0	1.43
224	0	8000	Minor	S	400	heb260	30	460	700	8 d25	No	7635858	50.1	1.32
225	0	8000	Major	S	400	heb260	30	550	500	8 d14	No	7934125	42.5	1.33
226	0	8000	Major	S	400	heb260	30	550	700	8 d25	No	8913735	45.9	1.28
227	0	8000	Minor	S	400	heb260	30	550	500	8 d14	No	6659083	49.0	1.40
228	0	8000	Minor	S	400	heb260	30	550	700	8 d25	No	7635880	50.1	1.30
229	0	8000	Major	S	400	heb260	60	355	500	8 d14	No	9953537	43.3	1.52
230	0	8000	Major	S	400	heb260	60	355	700	8 d25	No	10883130	42.5	1.40
231	0	8000	Minor	S	400	heb260	60	355	500	8 d14	No	8914133	48.9	1.55
232	0	8000	Minor	S	400	heb260	60	355	700	8 d25	No	9861191	46.4	1.40
233	0	8000	Major	S	400	heb260	60	460	500	8 d14	No	10315490	46.0	1.47
234	0	8000	Major	S	400	heb260	60	460	700	8 d25	No	11298964	44.6	1.38
235	0	8000	Minor	S	400	heb260	60	460	500	8 d14	No	9082300	50.7	1.50
236	0	8000	Minor	S	400	heb260	60	460	700	8 d25	No	10046148	51.5	1.36
237	0	8000	Major	S	400	heb260	60	550	500	8 d14	No	10325553	46.0	1.36
238	0	8000	Major	S	400	heb260	60	550	700	8 d25	No	11309476	44.6	1.29
239	0	8000	Minor	S	400	heb260	60	550	500	8 d14	No	9083058	50.7	1.47
240	0	8000	Minor	S	400	heb260	60	550	700	8 d25	No	10050605	51.5	1.34
241	0	8000	Major	S	400	heb260	90	355	500	8 d14	No	12469154	45.5	1.58
242	0	8000	Major	S	400	heb260	90	355	700	8 d25	No	13461855	45.3	1.46
243	0	8000	Minor	S	400	heb260	90	355	500	8 d14	No	11363094	48.5	1.61
244	0	8000	Minor	S	400	heb260	90	355	700	8 d25	No	12352056	47.2	1.46
245	0	8000	Major	S	400	heb260	90	460	500	8 d14	No	12999670	43.4	1.51

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
246	0	8000	Major	S	400	heb260	90	460	700	8 d25	No	14026180	42.9	1.41
247	0	8000	Minor	S	400	heb260	90	460	500	8 d14	No	11628788	49.6	1.55
248	0	8000	Minor	S	400	heb260	90	460	700	8 d25	No	12644025	48.1	1.41
249	0	8000	Major	S	400	heb260	90	550	500	8 d14	No	13014656	43.3	1.41
250	0	8000	Major	S	400	heb260	90	550	700	8 d25	No	14042608	42.9	1.33
251	0	8000	Minor	S	400	heb260	90	550	500	8 d14	No	11636070	49.6	1.52
252	0	8000	Minor	S	400	heb260	90	550	700	8 d25	No	12651457	48.1	1.39
253	0	10000	Major	S	400	heb260	30	355	500	8 d14	No	6077463	66.3	1.41
254	0	10000	Major	S	400	heb260	30	355	700	8 d25	No	6784622.5	68.0	1.32
255	0	10000	Minor	S	400	heb260	30	355	500	8 d14	No	5253150.5	64.4	1.45
256	0	10000	Minor	S	400	heb260	30	355	700	8 d25	No	5892261	66.1	1.33
257	0	10000	Major	S	400	heb260	30	460	500	8 d14	No	6123408.5	69.6	1.39
258	0	10000	Major	S	400	heb260	30	460	700	8 d25	No	6845855	71.1	1.31
259	0	10000	Minor	S	400	heb260	30	460	500	8 d14	No	5261227	64.3	1.42
260	0	10000	Minor	S	400	heb260	30	460	700	8 d25	No	5904181	66.1	1.31
261	0	10000	Major	S	400	heb260	30	550	500	8 d14	No	6123408.5	69.6	1.29
262	0	10000	Major	S	400	heb260	30	550	700	8 d25	No	6845855	71.1	1.24
263	0	10000	Minor	S	400	heb260	30	550	500	8 d14	No	5261227	64.3	1.40
264	0	10000	Minor	S	400	heb260	30	550	700	8 d25	No	5904181	66.1	1.29
265	0	10000	Major	S	400	heb260	60	355	500	8 d14	No	7654847	74.2	1.48
266	0	10000	Major	S	400	heb260	60	355	700	8 d25	No	8377448	73.0	1.37
267	0	10000	Minor	S	400	heb260	60	355	500	8 d14	No	6659683	75.7	1.52
268	0	10000	Minor	S	400	heb260	60	355	700	8 d25	No	7336177	73.1	1.38
269	0	10000	Major	S	400	heb260	60	460	500	8 d14	No	7745002	81.3	1.40
270	0	10000	Major	S	400	heb260	60	460	700	8 d25	No	8482375	83.5	1.31
271	0	10000	Minor	S	400	heb260	60	460	500	8 d14	No	6684863.5	75.5	1.47
272	0	10000	Minor	S	400	heb260	60	460	700	8 d25	No	7365129	77.6	1.34
273	0	10000	Major	S	400	heb260	60	550	500	8 d14	No	7745002	81.3	1.30
274	0	10000	Major	S	400	heb260	60	550	700	8 d25	No	8483682	83.5	1.23
275	0	10000	Minor	S	400	heb260	60	550	500	8 d14	No	6684863.5	75.5	1.46
276	0	10000	Minor	S	400	heb260	60	550	700	8 d25	No	7365129	77.6	1.32
277	0	10000	Major	S	400	heb260	90	355	500	8 d14	No	9358642	75.8	1.53
278	0	10000	Major	S	400	heb260	90	355	700	8 d25	No	10085066	76.0	1.41
279	0	10000	Minor	S	400	heb260	90	355	500	8 d14	No	8344964	77.4	1.57
280	0	10000	Minor	S	400	heb260	90	355	700	8 d25	No	9057845	75.9	1.42
281	0	10000	Major	S	400	heb260	90	460	500	8 d14	No	9487566	83.4	1.42
282	0	10000	Major	S	400	heb260	90	460	700	8 d25	No	10226858	83.2	1.33
283	0	10000	Minor	S	400	heb260	90	460	500	8 d14	No	8388297	82.3	1.51
284	0	10000	Minor	S	400	heb260	90	460	700	8 d25	No	9109268	80.5	1.37
285	0	10000	Major	S	400	heb260	90	550	500	8 d14	No	9487889	83.4	1.34
286	0	10000	Major	S	400	heb260	90	550	700	8 d25	No	10227365	83.2	1.26
287	0	10000	Minor	S	400	heb260	90	550	500	8 d14	No	8388297	82.3	1.50
288	0	10000	Minor	S	400	heb260	90	550	700	8 d25	No	9109268	80.5	1.36
289	0.1	3000	Major	C	450	heb220	30	355	500	8 d14	No	5991702	7.1	1.50
290	0.1	3000	Major	C	450	heb220	30	355	700	8 d25	No	6835005.5	7.2	1.36
291	0.1	3000	Major	S	400	heb260	30	355	500	8 d14	No	7172328	6.4	1.44
292	0.1	3000	Major	S	400	heb260	30	355	700	8 d25	No	8101953.5	6.4	1.33
293	0.1	3000	Minor	C	450	heb220	30	355	500	8 d14	No	5380088	7.6	1.50
294	0.1	3000	Minor	C	450	heb220	30	355	700	8 d25	No	6322186.5	8.0	1.36
295	0.1	3000	Minor	S	400	heb260	30	355	500	8 d14	No	6490577	7.6	1.44
296	0.1	3000	Minor	S	400	heb260	30	355	700	8 d25	No	8029119	10.6	1.34
297	0.1	3000	Major	C	450	heb220	30	460	500	8 d14	No	6647907	9.2	1.47
298	0.1	3000	Major	C	450	heb220	30	460	700	8 d25	No	7896283	9.9	1.36
299	0.1	3000	Major	S	400	heb260	30	460	500	8 d14	No	8003956	7.6	1.42

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
300	0.1	3000	Major	S	400	heb260	30	460	700	8 d25	No	9573837	9.3	1.33
301	0.1	3000	Minor	C	450	heb220	30	460	500	8 d14	No	5421177.5	7.5	1.47
302	0.1	3000	Minor	C	450	heb220	30	460	700	8 d25	No	6390525.5	7.9	1.35
303	0.1	3000	Minor	S	400	heb260	30	460	500	8 d14	No	6623147	7.4	1.42
304	0.1	3000	Minor	S	400	heb260	30	460	700	8 d25	No	8379066	10.2	1.32
305	0.1	3000	Major	C	450	heb220	30	550	500	8 d14	No	6734743.5	9.8	1.40
306	0.1	3000	Major	C	450	heb220	30	550	700	8 d25	No	7943611	9.8	1.32
307	0.1	3000	Major	S	400	heb260	30	550	500	8 d14	No	8026490	7.6	1.36
308	0.1	3000	Major	S	400	heb260	30	550	700	8 d25	No	9758296	9.0	1.29
309	0.1	3000	Minor	C	450	heb220	30	550	500	8 d14	No	5421177.5	7.5	1.42
310	0.1	3000	Minor	C	450	heb220	30	550	700	8 d25	No	6390525.5	7.9	1.31
311	0.1	3000	Minor	S	400	heb260	30	550	500	8 d14	No	6623147	7.4	1.36
312	0.1	3000	Minor	S	400	heb260	30	550	700	8 d25	No	8553698	10.7	1.28
313	0.1	3000	Major	C	450	heb220	60	355	500	8 d14	No	8575061	7.6	1.71
314	0.1	3000	Major	C	450	heb220	60	355	700	8 d25	No	9552016	7.8	1.51
315	0.1	3000	Major	S	400	heb260	60	355	500	8 d14	No	10108739	7.3	1.65
316	0.1	3000	Major	S	400	heb260	60	355	700	8 d25	No	11176317	7.4	1.48
317	0.1	3000	Minor	C	450	heb220	60	355	500	8 d14	No	8068194.5	8.2	1.70
318	0.1	3000	Minor	C	450	heb220	60	355	700	8 d25	No	9047822	8.2	1.50
319	0.1	3000	Minor	S	400	heb260	60	355	500	8 d14	No	9447713	8.3	1.65
320	0.1	3000	Minor	S	400	heb260	60	355	700	8 d25	No	10541216	8.3	1.48
321	0.1	3000	Major	C	450	heb220	60	460	500	8 d14	No	8723165	7.6	1.66
322	0.1	3000	Major	C	450	heb220	60	460	700	8 d25	No	9733132	7.7	1.49
323	0.1	3000	Major	S	400	heb260	60	460	500	8 d14	No	10733145	7.4	1.61
324	0.1	3000	Major	S	400	heb260	60	460	700	8 d25	No	11625272	7.2	1.47
325	0.1	3000	Minor	C	450	heb220	60	460	500	8 d14	No	8157662.5	8.1	1.62
326	0.1	3000	Minor	C	450	heb220	60	460	700	8 d25	No	9156995	8.1	1.46
327	0.1	3000	Minor	S	400	heb260	60	460	500	8 d14	No	9696725	8.1	1.58
328	0.1	3000	Minor	S	400	heb260	60	460	700	8 d25	No	10790422	8.1	1.44
329	0.1	3000	Major	C	450	heb220	60	550	500	8 d14	No	8723165	7.6	1.54
330	0.1	3000	Major	C	450	heb220	60	550	700	8 d25	No	9733132	7.7	1.41
331	0.1	3000	Major	S	400	heb260	60	550	500	8 d14	No	10768789	7.3	1.52
332	0.1	3000	Major	S	400	heb260	60	550	700	8 d25	No	11656655	7.1	1.41
333	0.1	3000	Minor	C	450	heb220	60	550	500	8 d14	No	8157662.5	8.1	1.52
334	0.1	3000	Minor	C	450	heb220	60	550	700	8 d25	No	9156995	8.1	1.39
335	0.1	3000	Minor	S	400	heb260	60	550	500	8 d14	No	9707104	8.1	1.48
336	0.1	3000	Minor	S	400	heb260	60	550	700	8 d25	No	10820722	8.1	1.37
337	0.1	3000	Major	C	450	heb220	90	355	500	8 d14	No	10834719	7.4	1.81
338	0.1	3000	Major	C	450	heb220	90	355	700	8 d25	No	11849869	7.7	1.61
339	0.1	3000	Major	S	400	heb260	90	355	500	8 d14	No	12607310	7.1	1.77
340	0.1	3000	Major	S	400	heb260	90	355	700	8 d25	No	13772579	7.3	1.59
341	0.1	3000	Minor	C	450	heb220	90	355	500	8 d14	No	10325353	7.7	1.80
342	0.1	3000	Minor	C	450	heb220	90	355	700	8 d25	No	11386855	7.8	1.61
343	0.1	3000	Minor	S	400	heb260	90	355	500	8 d14	No	11966477	7.8	1.77
344	0.1	3000	Minor	S	400	heb260	90	355	700	8 d25	No	13136805	7.9	1.59
345	0.1	3000	Major	C	450	heb220	90	460	500	8 d14	No	11016551	7.3	1.75
346	0.1	3000	Major	C	450	heb220	90	460	700	8 d25	No	12126446	7.5	1.58
347	0.1	3000	Major	S	400	heb260	90	460	500	8 d14	No	13365077	7.2	1.72
348	0.1	3000	Major	S	400	heb260	90	460	700	8 d25	No	14276929	7.0	1.57
349	0.1	3000	Minor	C	450	heb220	90	460	500	8 d14	No	10665138	8.1	1.71
350	0.1	3000	Minor	C	450	heb220	90	460	700	8 d25	No	11508438	7.8	1.55
351	0.1	3000	Minor	S	400	heb260	90	460	500	8 d14	No	12482491	8.2	1.68
352	0.1	3000	Minor	S	400	heb260	90	460	700	8 d25	No	13422334	7.7	1.53
353	0.1	3000	Major	C	450	heb220	90	550	500	8 d14	No	11016551	7.3	1.64

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
354	0.1	3000	Major	C	450	heb220	90	550	700	8 d25	No	12126519	7.5	1.49
355	0.1	3000	Major	S	400	heb260	90	550	500	8 d14	No	13415554	7.2	1.60
356	0.1	3000	Major	S	400	heb260	90	550	700	8 d25	No	14323820	7.0	1.48
357	0.1	3000	Minor	C	450	heb220	90	550	500	8 d14	No	10663992	8.1	1.62
358	0.1	3000	Minor	C	450	heb220	90	550	700	8 d25	No	11508438	7.8	1.48
359	0.1	3000	Minor	S	400	heb260	90	550	500	8 d14	No	12545668	8.0	1.58
360	0.1	3000	Minor	S	400	heb260	90	550	700	8 d25	No	13458474	7.7	1.45
361	0.1	6000	Major	C	450	heb220	30	355	500	8 d14	No	4799810	31.4	1.47
362	0.1	6000	Major	C	450	heb220	30	355	700	8 d25	No	5567494	33.3	1.36
363	0.1	6000	Major	S	400	heb260	30	355	500	8 d14	No	6065124	28.2	1.43
364	0.1	6000	Major	S	400	heb260	30	355	700	8 d25	No	6883066.5	29.0	1.34
365	0.1	6000	Minor	C	450	heb220	30	355	500	8 d14	No	4045926	34.3	1.50
366	0.1	6000	Minor	C	450	heb220	30	355	700	8 d25	No	4832874	34.7	1.36
367	0.1	6000	Minor	S	400	heb260	30	355	500	8 d14	No	5024713.5	33.5	1.45
368	0.1	6000	Minor	S	400	heb260	30	355	700	8 d25	No	5897271	34.3	1.34
369	0.1	6000	Major	C	450	heb220	30	460	500	8 d14	No	4816362.5	31.3	1.44
370	0.1	6000	Major	C	450	heb220	30	460	700	8 d25	No	5647445	34.6	1.35
371	0.1	6000	Major	S	400	heb260	30	460	500	8 d14	No	6590466	34.6	1.41
372	0.1	6000	Major	S	400	heb260	30	460	700	8 d25	No	7693812	40.4	1.33
373	0.1	6000	Minor	C	450	heb220	30	460	500	8 d14	No	4055419.25	34.2	1.47
374	0.1	6000	Minor	C	450	heb220	30	460	700	8 d25	No	4866509.5	36.6	1.34
375	0.1	6000	Minor	S	400	heb260	30	460	500	8 d14	No	5099436	35.2	1.43
376	0.1	6000	Minor	S	400	heb260	30	460	700	8 d25	No	6023424.5	35.4	1.32
377	0.1	6000	Major	C	450	heb220	30	550	500	8 d14	No	4816362.5	31.3	1.37
378	0.1	6000	Major	C	450	heb220	30	550	700	8 d25	No	5647445	34.6	1.29
379	0.1	6000	Major	S	400	heb260	30	550	500	8 d14	No	6594444	34.5	1.35
380	0.1	6000	Major	S	400	heb260	30	550	700	8 d25	No	7752998	40.1	1.29
381	0.1	6000	Minor	C	450	heb220	30	550	500	8 d14	No	4055419.25	34.2	1.46
382	0.1	6000	Minor	C	450	heb220	30	550	700	8 d25	No	4866509.5	36.6	1.33
383	0.1	6000	Minor	S	400	heb260	30	550	500	8 d14	No	5099436	35.2	1.39
384	0.1	6000	Minor	S	400	heb260	30	550	700	8 d25	No	6023424.5	35.4	1.29
385	0.1	6000	Major	C	450	heb220	60	355	500	8 d14	No	6705202.5	34.7	1.53
386	0.1	6000	Major	C	450	heb220	60	355	700	8 d25	No	7458653	34.0	1.41
387	0.1	6000	Major	S	400	heb260	60	355	500	8 d14	No	8357513.5	33.9	1.53
388	0.1	6000	Major	S	400	heb260	60	355	700	8 d25	No	9221022	33.6	1.41
389	0.1	6000	Minor	C	450	heb220	60	355	500	8 d14	No	5854260	36.2	1.54
390	0.1	6000	Minor	C	450	heb220	60	355	700	8 d25	No	6703116	35.7	1.40
391	0.1	6000	Minor	S	400	heb260	60	355	500	8 d14	No	7128523.5	37.4	1.54
392	0.1	6000	Minor	S	400	heb260	60	355	700	8 d25	No	8078089.5	36.8	1.41
393	0.1	6000	Major	C	450	heb220	60	460	500	8 d14	No	6762212.5	34.4	1.47
394	0.1	6000	Major	C	450	heb220	60	460	700	8 d25	No	7584729	35.3	1.36
395	0.1	6000	Major	S	400	heb260	60	460	500	8 d14	No	8718576	34.1	1.50
396	0.1	6000	Major	S	400	heb260	60	460	700	8 d25	No	9615395	33.8	1.40
397	0.1	6000	Minor	C	450	heb220	60	460	500	8 d14	No	5872245	36.1	1.50
398	0.1	6000	Minor	C	450	heb220	60	460	700	8 d25	No	6732435.5	35.6	1.36
399	0.1	6000	Minor	S	400	heb260	60	460	500	8 d14	No	7314635.5	38.4	1.49
400	0.1	6000	Minor	S	400	heb260	60	460	700	8 d25	No	8297550	37.7	1.37
401	0.1	6000	Major	C	450	heb220	60	550	500	8 d14	No	6762212.5	34.4	1.41
402	0.1	6000	Major	C	450	heb220	60	550	700	8 d25	No	7584729	35.3	1.31
403	0.1	6000	Major	S	400	heb260	60	550	500	8 d14	No	8724028	34.1	1.39
404	0.1	6000	Major	S	400	heb260	60	550	700	8 d25	No	9623987	33.7	1.31
405	0.1	6000	Minor	C	450	heb220	60	550	500	8 d14	No	5872245	36.1	1.49
406	0.1	6000	Minor	C	450	heb220	60	550	700	8 d25	No	6732435.5	35.6	1.35
407	0.1	6000	Minor	S	400	heb260	60	550	500	8 d14	No	7315018.5	38.4	1.46

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
408	0.1	6000	Minor	S	400	heb260	60	550	700	8 d25	No	8301107.5	37.7	1.34
409	0.1	6000	Major	C	450	heb220	90	355	500	8 d14	No	8353262.5	33.5	1.60
410	0.1	6000	Major	C	450	heb220	90	355	700	8 d25	No	9155366	33.2	1.47
411	0.1	6000	Major	S	400	heb260	90	355	500	8 d14	No	10325783	32.8	1.61
412	0.1	6000	Major	S	400	heb260	90	355	700	8 d25	No	11213100	33.0	1.48
413	0.1	6000	Minor	C	450	heb220	90	355	500	8 d14	No	7451527.5	35.4	1.59
414	0.1	6000	Minor	C	450	heb220	90	355	700	8 d25	No	8424758	35.5	1.45
415	0.1	6000	Minor	S	400	heb260	90	355	500	8 d14	No	9204915	37.3	1.61
416	0.1	6000	Minor	S	400	heb260	90	355	700	8 d25	No	10148459	35.8	1.47
417	0.1	6000	Major	C	450	heb220	90	460	500	8 d14	No	8535757	34.7	1.51
418	0.1	6000	Major	C	450	heb220	90	460	700	8 d25	No	9356943	34.4	1.40
419	0.1	6000	Major	S	400	heb260	90	460	500	8 d14	No	10753938	33.1	1.55
420	0.1	6000	Major	S	400	heb260	90	460	700	8 d25	No	11675606	33.2	1.44
421	0.1	6000	Minor	C	450	heb220	90	460	500	8 d14	No	7484420.5	35.3	1.55
422	0.1	6000	Minor	C	450	heb220	90	460	700	8 d25	No	8469490	35.3	1.41
423	0.1	6000	Minor	S	400	heb260	90	460	500	8 d14	No	9371500	36.4	1.55
424	0.1	6000	Minor	S	400	heb260	90	460	700	8 d25	No	10416326	37.1	1.42
425	0.1	6000	Major	C	450	heb220	90	550	500	8 d14	No	8535757	34.7	1.45
426	0.1	6000	Major	C	450	heb220	90	550	700	8 d25	No	9356943	34.4	1.35
427	0.1	6000	Major	S	400	heb260	90	550	500	8 d14	No	10760769	33.1	1.44
428	0.1	6000	Major	S	400	heb260	90	550	700	8 d25	No	11687924	33.2	1.35
429	0.1	6000	Minor	C	450	heb220	90	550	500	8 d14	No	7484420.5	35.3	1.54
430	0.1	6000	Minor	C	450	heb220	90	550	700	8 d25	No	8469490	35.3	1.40
431	0.1	6000	Minor	S	400	heb260	90	550	500	8 d14	No	9371917	36.4	1.51
432	0.1	6000	Minor	S	400	heb260	90	550	700	8 d25	No	10424898	36.8	1.39
433	0.1	8000	Major	C	450	heb220	30	355	500	8 d14	No	3742129.5	58.8	1.45
434	0.1	8000	Major	C	450	heb220	30	355	700	8 d25	No	4381047	64.8	1.34
435	0.1	8000	Major	S	400	heb260	30	355	500	8 d14	No	5050370	56.1	1.42
436	0.1	8000	Major	S	400	heb260	30	355	700	8 d25	No	5731726.5	58.8	1.33
437	0.1	8000	Minor	C	450	heb220	30	355	500	8 d14	No	3093346.75	55.7	1.50
438	0.1	8000	Minor	C	450	heb220	30	355	700	8 d25	No	3684091.5	61.7	1.35
439	0.1	8000	Minor	S	400	heb260	30	355	500	8 d14	No	3864535.25	55.1	1.46
440	0.1	8000	Minor	S	400	heb260	30	355	700	8 d25	No	4531368	61.5	1.33
441	0.1	8000	Major	C	450	heb220	30	460	500	8 d14	No	3746524.5	61.4	1.38
442	0.1	8000	Major	C	450	heb220	30	460	700	8 d25	No	4395741	64.7	1.30
443	0.1	8000	Major	S	400	heb260	30	460	500	8 d14	No	5126473	57.8	1.40
444	0.1	8000	Major	S	400	heb260	30	460	700	8 d25	No	5844877	60.2	1.32
445	0.1	8000	Minor	C	450	heb220	30	460	500	8 d14	No	3093346.75	55.7	1.48
446	0.1	8000	Minor	C	450	heb220	30	460	700	8 d25	No	3684091.5	61.7	1.33
447	0.1	8000	Minor	S	400	heb260	30	460	500	8 d14	No	3868133	55.0	1.43
448	0.1	8000	Minor	S	400	heb260	30	460	700	8 d25	No	4553898	64.2	1.31
449	0.1	8000	Major	C	450	heb220	30	550	500	8 d14	No	3746524.5	61.4	1.36
450	0.1	8000	Major	C	450	heb220	30	550	700	8 d25	No	4395741	64.7	1.28
451	0.1	8000	Major	S	400	heb260	30	550	500	8 d14	No	5126473	57.8	1.31
452	0.1	8000	Major	S	400	heb260	30	550	700	8 d25	No	5844877	60.2	1.25
453	0.1	8000	Minor	C	450	heb220	30	550	500	8 d14	No	3093346.75	55.7	1.48
454	0.1	8000	Minor	C	450	heb220	30	550	700	8 d25	No	3684091.5	61.7	1.33
455	0.1	8000	Minor	S	400	heb260	30	550	500	8 d14	No	3868133	55.0	1.40
456	0.1	8000	Minor	S	400	heb260	30	550	700	8 d25	No	4553898	64.2	1.29
457	0.1	8000	Major	C	450	heb220	60	355	500	8 d14	No	5022084	66.9	1.48
458	0.1	8000	Major	C	450	heb220	60	355	700	8 d25	No	5710869	68.6	1.37
459	0.1	8000	Major	S	400	heb260	60	355	500	8 d14	No	6547982.5	67.4	1.49
460	0.1	8000	Major	S	400	heb260	60	355	700	8 d25	No	7300142	67.3	1.38
461	0.1	8000	Minor	C	450	heb220	60	355	500	8 d14	No	4258734.5	62.9	1.52

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
462	0.1	8000	Minor	C	450	heb220	60	355	700	8 d25	No	4963084.5	65.8	1.37
463	0.1	8000	Minor	S	400	heb260	60	355	500	8 d14	No	5279067	60.4	1.54
464	0.1	8000	Minor	S	400	heb260	60	355	700	8 d25	No	6006493	65.1	1.39
465	0.1	8000	Major	C	450	heb220	60	460	500	8 d14	No	5036790	69.7	1.38
466	0.1	8000	Major	C	450	heb220	60	460	700	8 d25	No	5732569	68.4	1.29
467	0.1	8000	Major	S	400	heb260	60	460	500	8 d14	No	6747509.5	70.7	1.43
468	0.1	8000	Major	S	400	heb260	60	460	700	8 d25	No	7518419	68.1	1.34
469	0.1	8000	Minor	C	450	heb220	60	460	500	8 d14	No	4258728.5	62.9	1.50
470	0.1	8000	Minor	C	450	heb220	60	460	700	8 d25	No	4965615.5	65.8	1.34
471	0.1	8000	Minor	S	400	heb260	60	460	500	8 d14	No	5293871.5	60.2	1.50
472	0.1	8000	Minor	S	400	heb260	60	460	700	8 d25	No	6041610.5	64.8	1.35
473	0.1	8000	Major	C	450	heb220	60	550	500	8 d14	No	5036790	69.7	1.37
474	0.1	8000	Major	C	450	heb220	60	550	700	8 d25	No	5732569	68.4	1.28
475	0.1	8000	Major	S	400	heb260	60	550	500	8 d14	No	6749838	70.7	1.32
476	0.1	8000	Major	S	400	heb260	60	550	700	8 d25	No	7519667.5	68.1	1.25
477	0.1	8000	Minor	C	450	heb220	60	550	500	8 d14	No	4258728.5	62.9	1.50
478	0.1	8000	Minor	C	450	heb220	60	550	700	8 d25	No	4965615.5	65.8	1.34
479	0.1	8000	Minor	S	400	heb260	60	550	500	8 d14	No	5293871.5	60.2	1.47
480	0.1	8000	Minor	S	400	heb260	60	550	700	8 d25	No	6041610.5	64.8	1.33
481	0.1	8000	Major	C	450	heb220	90	355	500	8 d14	No	6214186.5	68.7	1.52
482	0.1	8000	Major	C	450	heb220	90	355	700	8 d25	No	6943630	68.3	1.39
483	0.1	8000	Major	S	400	heb260	90	355	500	8 d14	No	7969713.5	69.9	1.55
484	0.1	8000	Major	S	400	heb260	90	355	700	8 d25	No	8757780	67.6	1.43
485	0.1	8000	Minor	C	450	heb220	90	355	500	8 d14	No	5318001.5	67.4	1.56
486	0.1	8000	Minor	C	450	heb220	90	355	700	8 d25	No	6093140	71.4	1.39
487	0.1	8000	Minor	S	400	heb260	90	355	500	8 d14	No	6587743.5	63.7	1.60
488	0.1	8000	Minor	S	400	heb260	90	355	700	8 d25	No	7401259.5	69.2	1.44
489	0.1	8000	Major	C	450	heb220	90	460	500	8 d14	No	6242887	71.8	1.41
490	0.1	8000	Major	C	450	heb220	90	460	700	8 d25	No	6965691	68.2	1.31
491	0.1	8000	Major	S	400	heb260	90	460	500	8 d14	No	8184404	71.1	1.46
492	0.1	8000	Major	S	400	heb260	90	460	700	8 d25	No	8993799	68.8	1.37
493	0.1	8000	Minor	C	450	heb220	90	460	500	8 d14	No	5321082	71.5	1.53
494	0.1	8000	Minor	C	450	heb220	90	460	700	8 d25	No	6100376	71.3	1.37
495	0.1	8000	Minor	S	400	heb260	90	460	500	8 d14	No	6621164.5	67.4	1.54
496	0.1	8000	Minor	S	400	heb260	90	460	700	8 d25	No	7456756	72.2	1.39
497	0.1	8000	Major	C	450	heb220	90	550	500	8 d14	No	6242887	71.8	1.41
498	0.1	8000	Major	C	450	heb220	90	550	700	8 d25	No	6965691	68.2	1.30
499	0.1	8000	Major	S	400	heb260	90	550	500	8 d14	No	8186521	71.1	1.36
500	0.1	8000	Major	S	400	heb260	90	550	700	8 d25	No	8995551	68.8	1.28
501	0.1	8000	Minor	C	450	heb220	90	550	500	8 d14	No	5321082	71.5	1.53
502	0.1	8000	Minor	C	450	heb220	90	550	700	8 d25	No	6100376	71.3	1.37
503	0.1	8000	Minor	S	400	heb260	90	550	500	8 d14	No	6621164.5	67.4	1.52
504	0.1	8000	Minor	S	400	heb260	90	550	700	8 d25	No	7456756	72.2	1.37
505	0.1	10000	Major	C	450	heb220	30	355	500	8 d14	No	2862472.25	73.7	1.43
506	0.1	10000	Major	C	450	heb220	30	355	700	8 d25	No	3303173.5	82.8	1.33
507	0.1	10000	Major	S	400	heb260	30	355	500	8 d14	No	3894268.25	81.6	1.40
508	0.1	10000	Major	S	400	heb260	30	355	700	8 d25	No	4409364	87.7	1.31
509	0.1	10000	Minor	C	450	heb220	30	355	500	8 d14	No	2432803.5	65.6	1.49
510	0.1	10000	Minor	C	450	heb220	30	355	700	8 d25	No	2808493	72.6	1.34
511	0.1	10000	Minor	S	400	heb260	30	355	500	8 d14	No	2990789	67.4	1.45
512	0.1	10000	Minor	S	400	heb260	30	355	700	8 d25	No	3453533.75	73.5	1.33
513	0.1	10000	Major	C	450	heb220	30	460	500	8 d14	No	2862472.25	73.7	1.36
514	0.1	10000	Major	C	450	heb220	30	460	700	8 d25	No	3303173.5	82.8	1.28
515	0.1	10000	Major	S	400	heb260	30	460	500	8 d14	No	3897766.75	81.5	1.38

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
516	0.1	10000	Major	S	400	heb260	30	460	700	8 d25	No	4437713	108.0	1.30
517	0.1	10000	Minor	C	450	heb220	30	460	500	8 d14	No	2432803.5	65.6	1.47
518	0.1	10000	Minor	C	450	heb220	30	460	700	8 d25	No	2808493	72.6	1.32
519	0.1	10000	Minor	S	400	heb260	30	460	500	8 d14	No	2990789	67.4	1.42
520	0.1	10000	Minor	S	400	heb260	30	460	700	8 d25	No	3453533.75	73.5	1.31
521	0.1	10000	Major	C	450	heb220	30	550	500	8 d14	No	2862472.25	73.7	1.36
522	0.1	10000	Major	C	450	heb220	30	550	700	8 d25	No	3303173.5	82.8	1.27
523	0.1	10000	Major	S	400	heb260	30	550	500	8 d14	No	3897766.75	81.5	1.28
524	0.1	10000	Major	S	400	heb260	30	550	700	8 d25	No	4437713	108.0	1.22
525	0.1	10000	Minor	C	450	heb220	30	550	500	8 d14	No	2432803.5	65.6	1.47
526	0.1	10000	Minor	C	450	heb220	30	550	700	8 d25	No	2808493	72.6	1.32
527	0.1	10000	Minor	S	400	heb260	30	550	500	8 d14	No	2990789	67.4	1.40
528	0.1	10000	Minor	S	400	heb260	30	550	700	8 d25	No	3453533.75	73.5	1.29
529	0.1	10000	Major	C	450	heb220	60	355	500	8 d14	No	3679909	75.3	1.46
530	0.1	10000	Major	C	450	heb220	60	355	700	8 d25	No	4142121.5	86.2	1.33
531	0.1	10000	Major	S	400	heb260	60	355	500	8 d14	No	4873871.5	85.6	1.46
532	0.1	10000	Major	S	400	heb260	60	355	700	8 d25	No	5425734.5	89.1	1.35
533	0.1	10000	Minor	C	450	heb220	60	355	500	8 d14	No	3218263.75	71.8	1.50
534	0.1	10000	Minor	C	450	heb220	60	355	700	8 d25	No	3639408.75	75.9	1.35
535	0.1	10000	Minor	S	400	heb260	60	355	500	8 d14	No	3948908.25	72.1	1.52
536	0.1	10000	Minor	S	400	heb260	60	355	700	8 d25	No	4429861.5	76.4	1.37
537	0.1	10000	Major	C	450	heb220	60	460	500	8 d14	No	3679909	75.3	1.36
538	0.1	10000	Major	C	450	heb220	60	460	700	8 d25	No	4142121.5	86.2	1.26
539	0.1	10000	Major	S	400	heb260	60	460	500	8 d14	No	4879855.5	89.0	1.39
540	0.1	10000	Major	S	400	heb260	60	460	700	8 d25	No	5487169	126.2	1.26
541	0.1	10000	Minor	C	450	heb220	60	460	500	8 d14	No	3218263.75	71.8	1.49
542	0.1	10000	Minor	C	450	heb220	60	460	700	8 d25	No	3639408.75	75.9	1.33
543	0.1	10000	Minor	S	400	heb260	60	460	500	8 d14	No	3948908.25	72.1	1.48
544	0.1	10000	Minor	S	400	heb260	60	460	700	8 d25	No	4429861.5	76.4	1.34
545	0.1	10000	Major	C	450	heb220	60	550	500	8 d14	No	3679909	75.3	1.37
546	0.1	10000	Major	C	450	heb220	60	550	700	8 d25	No	4142121.5	86.2	1.26
547	0.1	10000	Major	S	400	heb260	60	550	500	8 d14	No	4879855.5	89.0	1.30
548	0.1	10000	Major	S	400	heb260	60	550	700	8 d25	No	5487676	126.2	1.20
549	0.1	10000	Minor	C	450	heb220	60	550	500	8 d14	No	3218263.75	71.8	1.48
550	0.1	10000	Minor	C	450	heb220	60	550	700	8 d25	No	3639408.75	75.9	1.33
551	0.1	10000	Minor	S	400	heb260	60	550	500	8 d14	No	3948908.25	72.1	1.46
552	0.1	10000	Minor	S	400	heb260	60	550	700	8 d25	No	4429861.5	76.4	1.32
553	0.1	10000	Major	C	450	heb220	90	355	500	8 d14	No	4368101	83.3	1.46
554	0.1	10000	Major	C	450	heb220	90	355	700	8 d25	No	4873350	94.4	1.33
555	0.1	10000	Major	S	400	heb260	90	355	500	8 d14	No	5713300	91.1	1.50
556	0.1	10000	Major	S	400	heb260	90	355	700	8 d25	No	6307631	101.2	1.38
557	0.1	10000	Minor	C	450	heb220	90	355	500	8 d14	No	3829975.75	76.6	1.53
558	0.1	10000	Minor	C	450	heb220	90	355	700	8 d25	No	4281954	85.1	1.35
559	0.1	10000	Minor	S	400	heb260	90	355	500	8 d14	No	4735991.5	84.2	1.56
560	0.1	10000	Minor	S	400	heb260	90	355	700	8 d25	No	5264699	83.7	1.41
561	0.1	10000	Major	C	450	heb220	90	460	500	8 d14	No	4368101	83.3	1.38
562	0.1	10000	Major	C	450	heb220	90	460	700	8 d25	No	4873350	94.4	1.26
563	0.1	10000	Major	S	400	heb260	90	460	500	8 d14	No	5722124	91.0	1.40
564	0.1	10000	Major	S	400	heb260	90	460	700	8 d25	No	6338700	104.2	1.29
565	0.1	10000	Minor	C	450	heb220	90	460	500	8 d14	No	3829975.75	76.6	1.51
566	0.1	10000	Minor	C	450	heb220	90	460	700	8 d25	No	4281954	85.1	1.34
567	0.1	10000	Minor	S	400	heb260	90	460	500	8 d14	No	4735991.5	84.2	1.51
568	0.1	10000	Minor	S	400	heb260	90	460	700	8 d25	No	5264699	83.7	1.37
569	0.1	10000	Major	C	450	heb220	90	550	500	8 d14	No	4368101	83.3	1.38

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
570	0.1	10000	Major	C	450	heb220	90	550	700	8 d25	No	4873350	94.4	1.26
571	0.1	10000	Major	S	400	heb260	90	550	500	8 d14	No	5722124	91.0	1.32
572	0.1	10000	Major	S	400	heb260	90	550	700	8 d25	No	6338700	104.2	1.23
573	0.1	10000	Minor	C	450	heb220	90	550	500	8 d14	No	3829975.75	76.6	1.51
574	0.1	10000	Minor	C	450	heb220	90	550	700	8 d25	No	4281954	85.1	1.34
575	0.1	10000	Minor	S	400	heb260	90	550	500	8 d14	No	4735991.5	84.2	1.50
576	0.1	10000	Minor	S	400	heb260	90	550	700	8 d25	No	5264699	83.7	1.36
577	0	3000	Major	C	450	heb220	50	355	500	8 d14	No	11989884	2.4	1.64
578	0	3000	Major	C	450	heb220	50	355	700	8 d25	No	13317396	2.3	1.48
579	0	3000	Major	S	400	heb260	50	355	500	8 d14	No	13017895	2.4	1.58
580	0	3000	Major	S	400	heb260	50	355	700	8 d25	No	14367011	2.3	1.45
581	0	3000	Minor	C	450	heb220	50	355	500	8 d14	No	11806820	2.7	1.64
582	0	3000	Minor	C	450	heb220	50	355	700	8 d25	No	13292895	2.7	1.48
583	0	3000	Minor	S	400	heb260	50	355	500	8 d14	No	12806015	3.1	1.58
584	0	3000	Minor	S	400	heb260	50	355	700	8 d25	No	14210740	2.7	1.45
585	0	3000	Major	C	450	heb220	50	460	500	8 d14	No	12926495	2.4	1.60
586	0	3000	Major	C	450	heb220	50	460	700	8 d25	No	14356450	2.3	1.47
587	0	3000	Major	S	400	heb260	50	460	500	8 d14	No	14273572	2.0	1.55
588	0	3000	Major	S	400	heb260	50	460	700	8 d25	No	15731758	2.0	1.43
589	0	3000	Minor	C	450	heb220	50	460	500	8 d14	No	12459782	2.6	1.60
590	0	3000	Minor	C	450	heb220	50	460	700	8 d25	No	13853621	2.4	1.46
591	0	3000	Minor	S	400	heb260	50	460	500	8 d14	No	13715816	2.8	1.54
592	0	3000	Minor	S	400	heb260	50	460	700	8 d25	No	15175226	2.5	1.43
593	0	3000	Major	C	450	heb220	50	550	500	8 d14	No	13017169	2.2	1.53
594	0	3000	Major	C	450	heb220	50	550	700	8 d25	No	14485342	2.1	1.42
595	0	3000	Major	S	400	heb260	50	550	500	8 d14	No	14639580	1.9	1.48
596	0	3000	Major	S	400	heb260	50	550	700	8 d25	No	15905994	1.7	1.39
597	0	3000	Minor	C	450	heb220	50	550	500	8 d14	No	12501825	2.5	1.53
598	0	3000	Minor	C	450	heb220	50	550	700	8 d25	No	14176576	2.5	1.42
599	0	3000	Minor	S	400	heb260	50	550	500	8 d14	No	14055344	2.7	1.47
600	0	3000	Minor	S	400	heb260	50	550	700	8 d25	No	15558618	2.4	1.38
601	0	6000	Major	C	450	heb220	50	355	500	8 d14	No	9906617	18.3	1.54
602	0	6000	Major	C	450	heb220	50	355	700	8 d25	No	11063875	19.0	1.43
603	0	6000	Major	S	400	heb260	50	355	500	8 d14	No	11092741	18.0	1.51
604	0	6000	Major	S	400	heb260	50	355	700	8 d25	No	12294836	18.6	1.41
605	0	6000	Minor	C	450	heb220	50	355	500	8 d14	No	9322800	20.6	1.54
606	0	6000	Minor	C	450	heb220	50	355	700	8 d25	No	10480922	20.5	1.43
607	0	6000	Minor	S	400	heb260	50	355	500	8 d14	No	10239740	22.2	1.51
608	0	6000	Minor	S	400	heb260	50	355	700	8 d25	No	11675186	27.0	1.41
609	0	6000	Major	C	450	heb220	50	460	500	8 d14	No	10235468	18.0	1.52
610	0	6000	Major	C	450	heb220	50	460	700	8 d25	No	11467440	18.2	1.42
611	0	6000	Major	S	400	heb260	50	460	500	8 d14	No	11926272	17.5	1.49
612	0	6000	Major	S	400	heb260	50	460	700	8 d25	No	13111334	16.6	1.41
613	0	6000	Minor	C	450	heb220	50	460	500	8 d14	No	9784290	26.0	1.51
614	0	6000	Minor	C	450	heb220	50	460	700	8 d25	No	11107056	27.3	1.41
615	0	6000	Minor	S	400	heb260	50	460	500	8 d14	No	10859150	26.7	1.49
616	0	6000	Minor	S	400	heb260	50	460	700	8 d25	No	12311868	27.1	1.39
617	0	6000	Major	C	450	heb220	50	550	500	8 d14	No	10726657	24.6	1.44
618	0	6000	Major	C	450	heb220	50	550	700	8 d25	No	12054656	24.0	1.36
619	0	6000	Major	S	400	heb260	50	550	500	8 d14	No	12333843	20.3	1.43
620	0	6000	Major	S	400	heb260	50	550	700	8 d25	No	13837483	24.0	1.36
621	0	6000	Minor	C	450	heb220	50	550	500	8 d14	No	9796130	26.0	1.50
622	0	6000	Minor	C	450	heb220	50	550	700	8 d25	No	11133169	27.2	1.39
623	0	6000	Minor	S	400	heb260	50	550	500	8 d14	No	10913756	26.3	1.45

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
624	0	6000	Minor	S	400	heb260	50	550	700	8 d25	No	12386768	26.7	1.36
625	0	8000	Major	C	450	heb220	50	355	500	8 d14	No	8006225	43.9	1.51
626	0	8000	Major	C	450	heb220	50	355	700	8 d25	No	8847628	43.1	1.41
627	0	8000	Major	S	400	heb260	50	355	500	8 d14	No	9113782	43.8	1.48
628	0	8000	Major	S	400	heb260	50	355	700	8 d25	No	10321159	43.1	1.40
629	0	8000	Minor	C	450	heb220	50	355	500	8 d14	No	7362499	45.8	1.55
630	0	8000	Minor	C	450	heb220	50	355	700	8 d25	No	8417884	52.7	1.41
631	0	8000	Minor	S	400	heb260	50	355	500	8 d14	No	8253466	50.6	1.53
632	0	8000	Minor	S	400	heb260	50	355	700	8 d25	No	9220838	50.4	1.40
633	0	8000	Major	C	450	heb220	50	460	500	8 d14	No	8317903	51.2	1.47
634	0	8000	Major	C	450	heb220	50	460	700	8 d25	No	9256682	52.3	1.38
635	0	8000	Major	S	400	heb260	50	460	500	8 d14	No	9703785	47.6	1.46
636	0	8000	Major	S	400	heb260	50	460	700	8 d25	No	10708576	48.8	1.39
637	0	8000	Minor	C	450	heb220	50	460	500	8 d14	No	7561558.5	52.2	1.53
638	0	8000	Minor	C	450	heb220	50	460	700	8 d25	No	8492676	52.2	1.39
639	0	8000	Minor	S	400	heb260	50	460	500	8 d14	No	8395306	52.9	1.50
640	0	8000	Minor	S	400	heb260	50	460	700	8 d25	No	9393214	52.3	1.39
641	0	8000	Major	C	450	heb220	50	550	500	8 d14	No	8318504	51.2	1.43
642	0	8000	Major	C	450	heb220	50	550	700	8 d25	No	9260216	52.3	1.34
643	0	8000	Major	S	400	heb260	50	550	500	8 d14	No	9717282	50.5	1.39
644	0	8000	Major	S	400	heb260	50	550	700	8 d25	No	10737689	51.7	1.33
645	0	8000	Minor	C	450	heb220	50	550	500	8 d14	No	7561558.5	52.2	1.52
646	0	8000	Minor	C	450	heb220	50	550	700	8 d25	No	8492676	52.2	1.39
647	0	8000	Minor	S	400	heb260	50	550	500	8 d14	No	8398276	52.9	1.47
648	0	8000	Minor	S	400	heb260	50	550	700	8 d25	No	9399183	55.6	1.36
649	0	10000	Major	C	450	heb220	50	355	500	8 d14	No	6063231	69.2	1.48
650	0	10000	Major	C	450	heb220	50	355	700	8 d25	No	6706310	72.1	1.38
651	0	10000	Major	S	400	heb260	50	355	500	8 d14	No	7086616	73.0	1.46
652	0	10000	Major	S	400	heb260	50	355	700	8 d25	No	8017966.5	69.3	1.37
653	0	10000	Minor	C	450	heb220	50	355	500	8 d14	No	5557778.5	69.6	1.53
654	0	10000	Minor	C	450	heb220	50	355	700	8 d25	No	6157825	67.9	1.39
655	0	10000	Minor	S	400	heb260	50	355	500	8 d14	No	6108910	71.6	1.51
656	0	10000	Minor	S	400	heb260	50	355	700	8 d25	No	6772983	73.2	1.39
657	0	10000	Major	C	450	heb220	50	460	500	8 d14	No	6072280	73.5	1.40
658	0	10000	Major	C	450	heb220	50	460	700	8 d25	No	6717706	72.0	1.33
659	0	10000	Major	S	400	heb260	50	460	500	8 d14	No	7376955	73.5	1.43
660	0	10000	Major	S	400	heb260	50	460	700	8 d25	No	8091423	76.5	1.36
661	0	10000	Minor	C	450	heb220	50	460	500	8 d14	No	5559967.5	69.6	1.51
662	0	10000	Minor	C	450	heb220	50	460	700	8 d25	No	6160874	72.6	1.37
663	0	10000	Minor	S	400	heb260	50	460	500	8 d14	No	6124463.5	76.4	1.48
664	0	10000	Minor	S	400	heb260	50	460	700	8 d25	No	6796005.5	77.6	1.37
665	0	10000	Major	C	450	heb220	50	550	500	8 d14	No	6072280	73.5	1.40
666	0	10000	Major	C	450	heb220	50	550	700	8 d25	No	6717706	72.0	1.32
667	0	10000	Major	S	400	heb260	50	550	500	8 d14	No	7376955	73.5	1.34
668	0	10000	Major	S	400	heb260	50	550	700	8 d25	No	8091423	76.5	1.28
669	0	10000	Minor	C	450	heb220	50	550	500	8 d14	No	5559967.5	69.6	1.51
670	0	10000	Minor	C	450	heb220	50	550	700	8 d25	No	6160874	72.6	1.37
671	0	10000	Minor	S	400	heb260	50	550	500	8 d14	No	6124463.5	76.4	1.47
672	0	10000	Minor	S	400	heb260	50	550	700	8 d25	No	6796005.5	77.6	1.35
673	0.1	3000	Major	C	450	heb220	50	355	500	8 d14	No	7719229	7.5	1.63
674	0.1	3000	Major	C	450	heb220	50	355	700	8 d25	No	8663081	7.5	1.47
675	0.1	3000	Major	S	400	heb260	50	355	500	8 d14	No	9329405	7.5	1.57
676	0.1	3000	Major	S	400	heb260	50	355	700	8 d25	No	10210731	7.2	1.44
677	0.1	3000	Minor	C	450	heb220	50	355	500	8 d14	No	7210144.5	8.1	1.63

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
678	0.1	3000	Minor	C	450	heb220	50	355	700	8 d25	No	8160310.5	8.0	1.47
679	0.1	3000	Minor	S	400	heb260	50	355	500	8 d14	No	8506205	8.2	1.57
680	0.1	3000	Minor	S	400	heb260	50	355	700	8 d25	No	9549498	8.1	1.44
681	0.1	3000	Major	C	450	heb220	50	460	500	8 d14	No	8025681.5	7.7	1.59
682	0.1	3000	Major	C	450	heb220	50	460	700	8 d25	No	8807765	7.5	1.46
683	0.1	3000	Major	S	400	heb260	50	460	500	8 d14	No	9734073	7.2	1.53
684	0.1	3000	Major	S	400	heb260	50	460	700	8 d25	No	10836147	7.3	1.43
685	0.1	3000	Minor	C	450	heb220	50	460	500	8 d14	No	7289209	8.0	1.58
686	0.1	3000	Minor	C	450	heb220	50	460	700	8 d25	No	8247871.5	8.0	1.45
687	0.1	3000	Minor	S	400	heb260	50	460	500	8 d14	No	8728981	8.0	1.53
688	0.1	3000	Minor	S	400	heb260	50	460	700	8 d25	No	9792975	7.9	1.42
689	0.1	3000	Major	C	450	heb220	50	550	500	8 d14	No	8025681.5	7.7	1.52
690	0.1	3000	Major	C	450	heb220	50	550	700	8 d25	No	8807765	7.5	1.41
691	0.1	3000	Major	S	400	heb260	50	550	500	8 d14	No	10171654	7.9	1.47
692	0.1	3000	Major	S	400	heb260	50	550	700	8 d25	No	11913987	9.2	1.38
693	0.1	3000	Minor	C	450	heb220	50	550	500	8 d14	No	7289209	8.0	1.50
694	0.1	3000	Minor	C	450	heb220	50	550	700	8 d25	No	8247871.5	8.0	1.39
695	0.1	3000	Minor	S	400	heb260	50	550	500	8 d14	No	8730103	8.0	1.46
696	0.1	3000	Minor	S	400	heb260	50	550	700	8 d25	No	9801380	7.9	1.37
697	0.1	6000	Major	C	450	heb220	50	355	500	8 d14	No	6105982.5	34.1	1.52
698	0.1	6000	Major	C	450	heb220	50	355	700	8 d25	No	6889218	34.7	1.42
699	0.1	6000	Major	S	400	heb260	50	355	500	8 d14	No	7668101	33.2	1.49
700	0.1	6000	Major	S	400	heb260	50	355	700	8 d25	No	8510270	32.8	1.40
701	0.1	6000	Minor	C	450	heb220	50	355	500	8 d14	No	5289930.5	35.9	1.54
702	0.1	6000	Minor	C	450	heb220	50	355	700	8 d25	No	6117311.5	37.0	1.41
703	0.1	6000	Minor	S	400	heb260	50	355	500	8 d14	No	6458179.5	37.4	1.52
704	0.1	6000	Minor	S	400	heb260	50	355	700	8 d25	No	7388351.5	36.4	1.40
705	0.1	6000	Major	C	450	heb220	50	460	500	8 d14	No	6150433	33.8	1.49
706	0.1	6000	Major	C	450	heb220	50	460	700	8 d25	No	6974620.5	34.3	1.40
707	0.1	6000	Major	S	400	heb260	50	460	500	8 d14	No	7992303.5	33.4	1.47
708	0.1	6000	Major	S	400	heb260	50	460	700	8 d25	No	8865922	33.0	1.39
709	0.1	6000	Minor	C	450	heb220	50	460	500	8 d14	No	5304094	35.9	1.52
710	0.1	6000	Minor	C	450	heb220	50	460	700	8 d25	No	6187790.5	36.8	1.40
711	0.1	6000	Minor	S	400	heb260	50	460	500	8 d14	No	6615361	38.5	1.50
712	0.1	6000	Minor	S	400	heb260	50	460	700	8 d25	No	7590645	37.3	1.39
713	0.1	6000	Major	C	450	heb220	50	550	500	8 d14	No	6150433	33.8	1.43
714	0.1	6000	Major	C	450	heb220	50	550	700	8 d25	No	6974620.5	34.3	1.34
715	0.1	6000	Major	S	400	heb260	50	550	500	8 d14	No	7994510	33.4	1.41
716	0.1	6000	Major	S	400	heb260	50	550	700	8 d25	No	8868880	33.0	1.35
717	0.1	6000	Minor	C	450	heb220	50	550	500	8 d14	No	5304094	35.9	1.51
718	0.1	6000	Minor	C	450	heb220	50	550	700	8 d25	No	6187790.5	36.8	1.39
719	0.1	6000	Minor	S	400	heb260	50	550	500	8 d14	No	6615360.5	38.5	1.46
720	0.1	6000	Minor	S	400	heb260	50	550	700	8 d25	No	7590568.5	37.3	1.36
721	0.1	8000	Major	C	450	heb220	50	355	500	8 d14	No	4623535	67.8	1.49
722	0.1	8000	Major	C	450	heb220	50	355	700	8 d25	No	5295475.5	68.9	1.39
723	0.1	8000	Major	S	400	heb260	50	355	500	8 d14	No	6074765.5	65.3	1.47
724	0.1	8000	Major	S	400	heb260	50	355	700	8 d25	No	6811012	65.3	1.38
725	0.1	8000	Minor	C	450	heb220	50	355	500	8 d14	No	3892243.5	58.0	1.54
726	0.1	8000	Minor	C	450	heb220	50	355	700	8 d25	No	4553246	64.5	1.40
727	0.1	8000	Minor	S	400	heb260	50	355	500	8 d14	No	4832211.5	59.5	1.53
728	0.1	8000	Minor	S	400	heb260	50	355	700	8 d25	No	5533016	63.9	1.40
729	0.1	8000	Major	C	450	heb220	50	460	500	8 d14	No	4634903.5	67.7	1.42
730	0.1	8000	Major	C	450	heb220	50	460	700	8 d25	No	5325209	68.7	1.34
731	0.1	8000	Major	S	400	heb260	50	460	500	8 d14	No	6250553	68.7	1.45

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
732	0.1	8000	Major	S	400	heb260	50	460	700	8 d25	No	7000545	66.2	1.37
733	0.1	8000	Minor	C	450	heb220	50	460	500	8 d14	No	3892243.5	58.0	1.52
734	0.1	8000	Minor	C	450	heb220	50	460	700	8 d25	No	4555095.5	64.5	1.38
735	0.1	8000	Minor	S	400	heb260	50	460	500	8 d14	No	4844822.5	59.4	1.50
736	0.1	8000	Minor	S	400	heb260	50	460	700	8 d25	No	5562859	63.7	1.38
737	0.1	8000	Major	C	450	heb220	50	550	500	8 d14	No	4634903.5	67.7	1.41
738	0.1	8000	Major	C	450	heb220	50	550	700	8 d25	No	5325209	68.7	1.33
739	0.1	8000	Major	S	400	heb260	50	550	500	8 d14	No	6250796	68.7	1.36
740	0.1	8000	Major	S	400	heb260	50	550	700	8 d25	No	7000715.5	66.2	1.30
741	0.1	8000	Minor	C	450	heb220	50	550	500	8 d14	No	3892243.5	58.0	1.52
742	0.1	8000	Minor	C	450	heb220	50	550	700	8 d25	No	4555095.5	64.5	1.38
743	0.1	8000	Minor	S	400	heb260	50	550	500	8 d14	No	4844822.5	59.4	1.47
744	0.1	8000	Minor	S	400	heb260	50	550	700	8 d25	No	5562859	63.7	1.36
745	0.1	10000	Major	C	450	heb220	50	355	500	8 d14	No	3428085.5	72.7	1.47
746	0.1	10000	Major	C	450	heb220	50	355	700	8 d25	No	3873483	83.4	1.37
747	0.1	10000	Major	S	400	heb260	50	355	500	8 d14	No	4570526.5	82.3	1.45
748	0.1	10000	Major	S	400	heb260	50	355	700	8 d25	No	5111109.5	88.9	1.36
749	0.1	10000	Minor	C	450	heb220	50	355	500	8 d14	No	3004658.75	69.0	1.53
750	0.1	10000	Minor	C	450	heb220	50	355	700	8 d25	No	3382004	73.6	1.39
751	0.1	10000	Minor	S	400	heb260	50	355	500	8 d14	No	3663423.75	70.1	1.51
752	0.1	10000	Minor	S	400	heb260	50	355	700	8 d25	No	4133796.75	74.1	1.39
753	0.1	10000	Major	C	450	heb220	50	460	500	8 d14	No	3428085.5	72.7	1.41
754	0.1	10000	Major	C	450	heb220	50	460	700	8 d25	No	3873483	83.4	1.32
755	0.1	10000	Major	S	400	heb260	50	460	500	8 d14	No	4575134.5	85.6	1.43
756	0.1	10000	Major	S	400	heb260	50	460	700	8 d25	No	5191268.5	122.2	1.32
757	0.1	10000	Minor	C	450	heb220	50	460	500	8 d14	No	3004658.75	69.0	1.51
758	0.1	10000	Minor	C	450	heb220	50	460	700	8 d25	No	3382004	73.6	1.37
759	0.1	10000	Minor	S	400	heb260	50	460	500	8 d14	No	3663423.75	70.1	1.48
760	0.1	10000	Minor	S	400	heb260	50	460	700	8 d25	No	4133796.75	74.1	1.37
761	0.1	10000	Major	C	450	heb220	50	550	500	8 d14	No	3428085.5	72.7	1.40
762	0.1	10000	Major	C	450	heb220	50	550	700	8 d25	No	3873483	83.4	1.31
763	0.1	10000	Major	S	400	heb260	50	550	500	8 d14	No	4575134.5	85.6	1.33
764	0.1	10000	Major	S	400	heb260	50	550	700	8 d25	No	5191453	122.2	1.26
765	0.1	10000	Minor	C	450	heb220	50	550	500	8 d14	No	3004658.75	69.0	1.51
766	0.1	10000	Minor	C	450	heb220	50	550	700	8 d25	No	3382004	73.6	1.37
767	0.1	10000	Minor	S	400	heb260	50	550	500	8 d14	No	3663423.75	70.1	1.47
768	0.1	10000	Minor	S	400	heb260	50	550	700	8 d25	No	4133796.75	74.1	1.35
769	0.2	3000	Major	C	450	heb220	30	355	500	8 d14	No	4172308.25	10.1	1.50
770	0.2	3000	Major	C	450	heb220	30	355	700	8 d25	No	4938756	11.0	1.36
771	0.2	3000	Major	S	400	heb260	30	355	500	8 d14	No	5471043.5	8.3	1.44
772	0.2	3000	Major	S	400	heb260	30	355	700	8 d25	No	6326771	8.7	1.34
773	0.2	3000	Minor	C	450	heb220	30	355	500	8 d14	No	3409213.25	10.5	1.50
774	0.2	3000	Minor	C	450	heb220	30	355	700	8 d25	No	4193715.5	11.1	1.36
775	0.2	3000	Minor	S	400	heb260	30	355	500	8 d14	No	4441963.5	10.0	1.44
776	0.2	3000	Minor	S	400	heb260	30	355	700	8 d25	No	5321817	10.0	1.34
777	0.2	3000	Major	C	450	heb220	30	460	500	8 d14	No	4201151.5	10.0	1.47
778	0.2	3000	Major	C	450	heb220	30	460	700	8 d25	No	5021393	10.8	1.36
779	0.2	3000	Major	S	400	heb260	30	460	500	8 d14	No	6062298	9.8	1.42
780	0.2	3000	Major	S	400	heb260	30	460	700	8 d25	No	7432969	11.9	1.33
781	0.2	3000	Minor	C	450	heb220	30	460	500	8 d14	No	3410341.75	10.5	1.47
782	0.2	3000	Minor	C	450	heb220	30	460	700	8 d25	No	4242233	11.8	1.34
783	0.2	3000	Minor	S	400	heb260	30	460	500	8 d14	No	4584541	10.4	1.41
784	0.2	3000	Minor	S	400	heb260	30	460	700	8 d25	No	5478887.5	10.5	1.32
785	0.2	3000	Major	C	450	heb220	30	550	500	8 d14	No	4201151.5	10.0	1.40

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
786	0.2	3000	Major	C	450	heb220	30	550	700	8 d25	No	5044762.5	18.7	1.30
787	0.2	3000	Major	S	400	heb260	30	550	500	8 d14	No	6064031.5	9.8	1.36
788	0.2	3000	Major	S	400	heb260	30	550	700	8 d25	No	7558010	11.8	1.29
789	0.2	3000	Minor	C	450	heb220	30	550	500	8 d14	No	3410341.75	10.5	1.42
790	0.2	3000	Minor	C	450	heb220	30	550	700	8 d25	No	4242233	11.8	1.31
791	0.2	3000	Minor	S	400	heb260	30	550	500	8 d14	No	4584541	10.4	1.37
792	0.2	3000	Minor	S	400	heb260	30	550	700	8 d25	No	5478887.5	10.5	1.28
793	0.2	3000	Major	C	450	heb220	50	355	500	8 d14	No	5310471.5	10.2	1.62
794	0.2	3000	Major	C	450	heb220	50	355	700	8 d25	No	6053961.5	10.1	1.47
795	0.2	3000	Major	S	400	heb260	50	355	500	8 d14	No	7076806	9.8	1.56
796	0.2	3000	Major	S	400	heb260	50	355	700	8 d25	No	7808179	9.4	1.44
797	0.2	3000	Minor	C	450	heb220	50	355	500	8 d14	No	4501003	11.3	1.62
798	0.2	3000	Minor	C	450	heb220	50	355	700	8 d25	No	5387228	11.1	1.46
799	0.2	3000	Minor	S	400	heb260	50	355	500	8 d14	No	5866555.5	11.1	1.56
800	0.2	3000	Minor	S	400	heb260	50	355	700	8 d25	No	6851419	11.1	1.43
801	0.2	3000	Major	C	450	heb220	50	460	500	8 d14	No	5344425.5	10.2	1.58
802	0.2	3000	Major	C	450	heb220	50	460	700	8 d25	No	6101499.5	10.0	1.45
803	0.2	3000	Major	S	400	heb260	50	460	500	8 d14	No	7345066.5	9.7	1.53
804	0.2	3000	Major	S	400	heb260	50	460	700	8 d25	No	8245345	9.6	1.42
805	0.2	3000	Minor	C	450	heb220	50	460	500	8 d14	No	4514742	11.2	1.56
806	0.2	3000	Minor	C	450	heb220	50	460	700	8 d25	No	5419448.5	11.0	1.43
807	0.2	3000	Minor	S	400	heb260	50	460	500	8 d14	No	6093060	11.5	1.51
808	0.2	3000	Minor	S	400	heb260	50	460	700	8 d25	No	7012780	10.9	1.40
809	0.2	3000	Major	C	450	heb220	50	550	500	8 d14	No	5344425.5	10.2	1.50
810	0.2	3000	Major	C	450	heb220	50	550	700	8 d25	No	6101499.5	10.0	1.40
811	0.2	3000	Major	S	400	heb260	50	550	500	8 d14	No	7345553	9.7	1.46
812	0.2	3000	Major	S	400	heb260	50	550	700	8 d25	No	8253368	9.6	1.38
813	0.2	3000	Minor	C	450	heb220	50	550	500	8 d14	No	4514742	11.2	1.50
814	0.2	3000	Minor	C	450	heb220	50	550	700	8 d25	No	5419448.5	11.0	1.39
815	0.2	3000	Minor	S	400	heb260	50	550	500	8 d14	No	6093060	11.5	1.46
816	0.2	3000	Minor	S	400	heb260	50	550	700	8 d25	No	7012780	10.9	1.37
817	0.2	3000	Major	C	450	heb220	60	355	500	8 d14	No	5881288.5	10.6	1.68
818	0.2	3000	Major	C	450	heb220	60	355	700	8 d25	No	6647253	10.5	1.49
819	0.2	3000	Major	S	400	heb260	60	355	500	8 d14	No	7649674	9.8	1.63
820	0.2	3000	Major	S	400	heb260	60	355	700	8 d25	No	8532305	9.8	1.47
821	0.2	3000	Minor	C	450	heb220	60	355	500	8 d14	No	5055643.5	11.5	1.67
822	0.2	3000	Minor	C	450	heb220	60	355	700	8 d25	No	5868465	10.9	1.48
823	0.2	3000	Minor	S	400	heb260	60	355	500	8 d14	No	6534310	11.4	1.62
824	0.2	3000	Minor	S	400	heb260	60	355	700	8 d25	No	7454890.5	10.9	1.46
825	0.2	3000	Major	C	450	heb220	60	460	500	8 d14	No	5931780	10.6	1.62
826	0.2	3000	Major	C	450	heb220	60	460	700	8 d25	No	6722645.5	10.5	1.47
827	0.2	3000	Major	S	400	heb260	60	460	500	8 d14	No	7919882	9.6	1.59
828	0.2	3000	Major	S	400	heb260	60	460	700	8 d25	No	8840070	9.6	1.46
829	0.2	3000	Minor	C	450	heb220	60	460	500	8 d14	No	5077551.5	11.5	1.58
830	0.2	3000	Minor	C	450	heb220	60	460	700	8 d25	No	5895066	10.9	1.43
831	0.2	3000	Minor	S	400	heb260	60	460	500	8 d14	No	6668183	11.2	1.55
832	0.2	3000	Minor	S	400	heb260	60	460	700	8 d25	No	7594621.5	10.8	1.42
833	0.2	3000	Major	C	450	heb220	60	550	500	8 d14	No	5931780	10.6	1.51
834	0.2	3000	Major	C	450	heb220	60	550	700	8 d25	No	6722645.5	10.5	1.39
835	0.2	3000	Major	S	400	heb260	60	550	500	8 d14	No	8024619.5	10.1	1.49
836	0.2	3000	Major	S	400	heb260	60	550	700	8 d25	No	8846636	9.6	1.39
837	0.2	3000	Minor	C	450	heb220	60	550	500	8 d14	No	5077551.5	11.5	1.51
838	0.2	3000	Minor	C	450	heb220	60	550	700	8 d25	No	5895066	10.9	1.39
839	0.2	3000	Minor	S	400	heb260	60	550	500	8 d14	No	6668183	11.2	1.47

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
840	0.2	3000	Minor	S	400	heb260	60	550	700	8 d25	No	7594621.5	10.8	1.37
841	0.2	3000	Major	C	450	heb220	90	355	500	8 d14	No	7255126.5	10.3	1.77
842	0.2	3000	Major	C	450	heb220	90	355	700	8 d25	No	8078410.5	10.3	1.58
843	0.2	3000	Major	S	400	heb260	90	355	500	8 d14	No	9509144	9.9	1.74
844	0.2	3000	Major	S	400	heb260	90	355	700	8 d25	No	10258730	9.6	1.57
845	0.2	3000	Minor	C	450	heb220	90	355	500	8 d14	No	6401534.5	10.9	1.76
846	0.2	3000	Minor	C	450	heb220	90	355	700	8 d25	No	7338650	11.1	1.57
847	0.2	3000	Minor	S	400	heb260	90	355	500	8 d14	No	8377072.5	11.1	1.73
848	0.2	3000	Minor	S	400	heb260	90	355	700	8 d25	No	9358996	10.8	1.56
849	0.2	3000	Major	C	450	heb220	90	460	500	8 d14	No	7306699.5	10.3	1.71
850	0.2	3000	Major	C	450	heb220	90	460	700	8 d25	No	8144988.5	10.3	1.55
851	0.2	3000	Major	S	400	heb260	90	460	500	8 d14	No	9828175	9.8	1.70
852	0.2	3000	Major	S	400	heb260	90	460	700	8 d25	No	10812179	9.8	1.55
853	0.2	3000	Minor	C	450	heb220	90	460	500	8 d14	No	6420888	10.9	1.67
854	0.2	3000	Minor	C	450	heb220	90	460	700	8 d25	No	7446552.5	11.0	1.51
855	0.2	3000	Minor	S	400	heb260	90	460	500	8 d14	No	8522152	11.0	1.65
856	0.2	3000	Minor	S	400	heb260	90	460	700	8 d25	No	9518521	10.7	1.51
857	0.2	3000	Major	C	450	heb220	90	550	500	8 d14	No	7306699.5	10.3	1.60
858	0.2	3000	Major	C	450	heb220	90	550	700	8 d25	No	8144988.5	10.3	1.46
859	0.2	3000	Major	S	400	heb260	90	550	500	8 d14	No	9836268	9.8	1.58
860	0.2	3000	Major	S	400	heb260	90	550	700	8 d25	No	10832524	9.8	1.45
861	0.2	3000	Minor	C	450	heb220	90	550	500	8 d14	No	6420888	10.9	1.60
862	0.2	3000	Minor	C	450	heb220	90	550	700	8 d25	No	7446552.5	11.0	1.47
863	0.2	3000	Minor	S	400	heb260	90	550	500	8 d14	No	8522152	11.0	1.57
864	0.2	3000	Minor	S	400	heb260	90	550	700	8 d25	No	9518831	10.7	1.45
865	0.2	6000	Major	C	450	heb220	30	355	500	8 d14	No	3302134.75	42.6	1.47
866	0.2	6000	Major	C	450	heb220	30	355	700	8 d25	No	3932369.25	44.7	1.36
867	0.2	6000	Major	S	400	heb260	30	355	500	8 d14	No	4562119.5	37.4	1.43
868	0.2	6000	Major	S	400	heb260	30	355	700	8 d25	No	5260280	39.3	1.34
869	0.2	6000	Minor	C	450	heb220	30	355	500	8 d14	No	2525772.25	45.4	1.50
870	0.2	6000	Minor	C	450	heb220	30	355	700	8 d25	No	3233917.25	46.5	1.36
871	0.2	6000	Minor	S	400	heb260	30	355	500	8 d14	No	3329561	44.3	1.46
872	0.2	6000	Minor	S	400	heb260	30	355	700	8 d25	No	4132667.75	45.8	1.34
873	0.2	6000	Major	C	450	heb220	30	460	500	8 d14	No	3309755.75	42.5	1.42
874	0.2	6000	Major	C	450	heb220	30	460	700	8 d25	No	3966305.5	45.9	1.33
875	0.2	6000	Major	S	400	heb260	30	460	500	8 d14	No	4667712	38.3	1.41
876	0.2	6000	Major	S	400	heb260	30	460	700	8 d25	No	5368360	38.5	1.33
877	0.2	6000	Minor	C	450	heb220	30	460	500	8 d14	No	2526462.25	45.4	1.47
878	0.2	6000	Minor	C	450	heb220	30	460	700	8 d25	No	3241528.5	46.5	1.34
879	0.2	6000	Minor	S	400	heb260	30	460	500	8 d14	No	3387902.5	47.1	1.43
880	0.2	6000	Minor	S	400	heb260	30	460	700	8 d25	No	4221674	46.7	1.32
881	0.2	6000	Major	C	450	heb220	30	550	500	8 d14	No	3309755.75	42.5	1.37
882	0.2	6000	Major	C	450	heb220	30	550	700	8 d25	No	3966305.5	45.9	1.28
883	0.2	6000	Major	S	400	heb260	30	550	500	8 d14	No	4667712	38.3	1.34
884	0.2	6000	Major	S	400	heb260	30	550	700	8 d25	No	5368360	38.5	1.28
885	0.2	6000	Minor	C	450	heb220	30	550	500	8 d14	No	2526462.25	45.4	1.48
886	0.2	6000	Minor	C	450	heb220	30	550	700	8 d25	No	3241528.5	46.5	1.33
887	0.2	6000	Minor	S	400	heb260	30	550	500	8 d14	No	3387902.5	47.1	1.40
888	0.2	6000	Minor	S	400	heb260	30	550	700	8 d25	No	4221674	46.7	1.29
889	0.2	6000	Major	C	450	heb220	50	355	500	8 d14	No	4132833.75	45.4	1.51
890	0.2	6000	Major	C	450	heb220	50	355	700	8 d25	No	4735706.5	43.6	1.41
891	0.2	6000	Major	S	400	heb260	50	355	500	8 d14	No	5618475	42.7	1.49
892	0.2	6000	Major	S	400	heb260	50	355	700	8 d25	No	6355968.5	42.7	1.40
893	0.2	6000	Minor	C	450	heb220	50	355	500	8 d14	No	3218628	48.7	1.55

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
894	0.2	6000	Minor	C	450	heb220	50	355	700	8 d25	No	4033857	48.6	1.41
895	0.2	6000	Minor	S	400	heb260	50	355	500	8 d14	No	4243074	50.1	1.53
896	0.2	6000	Minor	S	400	heb260	50	355	700	8 d25	No	5104576	48.5	1.41
897	0.2	6000	Major	C	450	heb220	50	460	500	8 d14	No	4151053.75	45.2	1.47
898	0.2	6000	Major	C	450	heb220	50	460	700	8 d25	No	4777475.5	44.8	1.39
899	0.2	6000	Major	S	400	heb260	50	460	500	8 d14	No	5814484	43.2	1.47
900	0.2	6000	Major	S	400	heb260	50	460	700	8 d25	No	6523758	42.2	1.39
901	0.2	6000	Minor	C	450	heb220	50	460	500	8 d14	No	3219500.75	48.6	1.53
902	0.2	6000	Minor	C	450	heb220	50	460	700	8 d25	No	3979113	46.7	1.39
903	0.2	6000	Minor	S	400	heb260	50	460	500	8 d14	No	4346220.5	51.0	1.50
904	0.2	6000	Minor	S	400	heb260	50	460	700	8 d25	No	5212673.5	49.5	1.39
905	0.2	6000	Major	C	450	heb220	50	550	500	8 d14	No	4151053.75	45.2	1.43
906	0.2	6000	Major	C	450	heb220	50	550	700	8 d25	No	4777475.5	44.8	1.34
907	0.2	6000	Major	S	400	heb260	50	550	500	8 d14	No	5814545	43.2	1.39
908	0.2	6000	Major	S	400	heb260	50	550	700	8 d25	No	6524236	42.2	1.33
909	0.2	6000	Minor	C	450	heb220	50	550	500	8 d14	No	3219500.75	48.6	1.52
910	0.2	6000	Minor	C	450	heb220	50	550	700	8 d25	No	3979113	46.7	1.39
911	0.2	6000	Minor	S	400	heb260	50	550	500	8 d14	No	4346220.5	51.0	1.47
912	0.2	6000	Minor	S	400	heb260	50	550	700	8 d25	No	5212673.5	49.5	1.36
913	0.2	6000	Major	C	450	heb220	60	355	500	8 d14	No	4448347.5	45.8	1.52
914	0.2	6000	Major	C	450	heb220	60	355	700	8 d25	No	5136332.5	44.9	1.40
915	0.2	6000	Major	S	400	heb260	60	355	500	8 d14	No	6095598.5	44.0	1.52
916	0.2	6000	Major	S	400	heb260	60	355	700	8 d25	No	6807901	42.8	1.40
917	0.2	6000	Minor	C	450	heb220	60	355	500	8 d14	No	3554174	50.0	1.54
918	0.2	6000	Minor	C	450	heb220	60	355	700	8 d25	No	4328432	48.3	1.39
919	0.2	6000	Minor	S	400	heb260	60	355	500	8 d14	No	4641612.5	51.7	1.55
920	0.2	6000	Minor	S	400	heb260	60	355	700	8 d25	No	5540989	50.1	1.40
921	0.2	6000	Major	C	450	heb220	60	460	500	8 d14	No	4461778	45.7	1.44
922	0.2	6000	Major	C	450	heb220	60	460	700	8 d25	No	5161045.5	47.7	1.34
923	0.2	6000	Major	S	400	heb260	60	460	500	8 d14	No	6313129.5	44.5	1.48
924	0.2	6000	Major	S	400	heb260	60	460	700	8 d25	No	7043543	43.5	1.39
925	0.2	6000	Minor	C	450	heb220	60	460	500	8 d14	No	3559200.75	50.0	1.50
926	0.2	6000	Minor	C	450	heb220	60	460	700	8 d25	No	4338466	48.2	1.36
927	0.2	6000	Minor	S	400	heb260	60	460	500	8 d14	No	4740625	52.8	1.50
928	0.2	6000	Minor	S	400	heb260	60	460	700	8 d25	No	5634682.5	49.5	1.37
929	0.2	6000	Major	C	450	heb220	60	550	500	8 d14	No	4461778	45.7	1.40
930	0.2	6000	Major	C	450	heb220	60	550	700	8 d25	No	5161983.5	47.7	1.30
931	0.2	6000	Major	S	400	heb260	60	550	500	8 d14	No	6313012	44.5	1.37
932	0.2	6000	Major	S	400	heb260	60	550	700	8 d25	No	7044398	43.5	1.29
933	0.2	6000	Minor	C	450	heb220	60	550	500	8 d14	No	3559200.75	50.0	1.50
934	0.2	6000	Minor	C	450	heb220	60	550	700	8 d25	No	4338466	48.2	1.35
935	0.2	6000	Minor	S	400	heb260	60	550	500	8 d14	No	4740625	52.8	1.47
936	0.2	6000	Minor	S	400	heb260	60	550	700	8 d25	No	5634682.5	49.5	1.34
937	0.2	6000	Major	C	450	heb220	90	355	500	8 d14	No	5399280	46.0	1.58
938	0.2	6000	Major	C	450	heb220	90	355	700	8 d25	No	6162043.5	45.0	1.45
939	0.2	6000	Major	S	400	heb260	90	355	500	8 d14	No	7346319.5	43.8	1.59
940	0.2	6000	Major	S	400	heb260	90	355	700	8 d25	No	8144277.5	44.3	1.47
941	0.2	6000	Minor	C	450	heb220	90	355	500	8 d14	No	4446971.5	49.4	1.58
942	0.2	6000	Minor	C	450	heb220	90	355	700	8 d25	No	5295831.5	48.1	1.43
943	0.2	6000	Minor	S	400	heb260	90	355	500	8 d14	No	5765783	53.3	1.61
944	0.2	6000	Minor	S	400	heb260	90	355	700	8 d25	No	6754133.5	49.7	1.46
945	0.2	6000	Major	C	450	heb220	90	460	500	8 d14	No	5411681	45.9	1.48
946	0.2	6000	Major	C	450	heb220	90	460	700	8 d25	No	6182026	45.0	1.37
947	0.2	6000	Major	S	400	heb260	90	460	500	8 d14	No	7572052	44.7	1.52

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
948	0.2	6000	Major	S	400	heb260	90	460	700	8 d25	No	8336438	43.7	1.42
949	0.2	6000	Minor	C	450	heb220	90	460	500	8 d14	No	4484244.5	51.3	1.55
950	0.2	6000	Minor	C	450	heb220	90	460	700	8 d25	No	5301552	48.0	1.39
951	0.2	6000	Minor	S	400	heb260	90	460	500	8 d14	No	5865214.5	52.5	1.55
952	0.2	6000	Minor	S	400	heb260	90	460	700	8 d25	No	6893742	50.8	1.41
953	0.2	6000	Major	C	450	heb220	90	550	500	8 d14	No	5411681	45.9	1.44
954	0.2	6000	Major	C	450	heb220	90	550	700	8 d25	No	6182026	45.0	1.33
955	0.2	6000	Major	S	400	heb260	90	550	500	8 d14	No	7572543.5	44.7	1.42
956	0.2	6000	Major	S	400	heb260	90	550	700	8 d25	No	8337336	43.7	1.33
957	0.2	6000	Minor	C	450	heb220	90	550	500	8 d14	No	4484244.5	51.3	1.54
958	0.2	6000	Minor	C	450	heb220	90	550	700	8 d25	No	5301552	48.0	1.39
959	0.2	6000	Minor	S	400	heb260	90	550	500	8 d14	No	5865214.5	52.5	1.52
960	0.2	6000	Minor	S	400	heb260	90	550	700	8 d25	No	6893742	50.8	1.39
961	0.2	8000	Major	C	450	heb220	30	355	500	8 d14	No	2671461.5	80.9	1.43
962	0.2	8000	Major	C	450	heb220	30	355	700	8 d25	No	3201540.25	78.2	1.33
963	0.2	8000	Major	S	400	heb260	30	355	500	8 d14	No	3779212.25	71.6	1.41
964	0.2	8000	Major	S	400	heb260	30	355	700	8 d25	No	4378932	72.1	1.32
965	0.2	8000	Minor	C	450	heb220	30	355	500	8 d14	No	1949973.375	78.1	1.48
966	0.2	8000	Minor	C	450	heb220	30	355	700	8 d25	No	2551715	84.6	1.34
967	0.2	8000	Minor	S	400	heb260	30	355	500	8 d14	No	2631454.25	80.2	1.45
968	0.2	8000	Minor	S	400	heb260	30	355	700	8 d25	No	3254072.25	79.5	1.33
969	0.2	8000	Major	C	450	heb220	30	460	500	8 d14	No	2676381.75	80.9	1.35
970	0.2	8000	Major	C	450	heb220	30	460	700	8 d25	No	3208188.75	79.8	1.28
971	0.2	8000	Major	S	400	heb260	30	460	500	8 d14	No	3843507.75	72.8	1.39
972	0.2	8000	Major	S	400	heb260	30	460	700	8 d25	No	4466446	73.1	1.32
973	0.2	8000	Minor	C	450	heb220	30	460	500	8 d14	No	1949973.375	78.1	1.46
974	0.2	8000	Minor	C	450	heb220	30	460	700	8 d25	No	2554133.5	86.4	1.32
975	0.2	8000	Minor	S	400	heb260	30	460	500	8 d14	No	2641501.5	82.1	1.41
976	0.2	8000	Minor	S	400	heb260	30	460	700	8 d25	No	3285448.75	86.7	1.30
977	0.2	8000	Major	C	450	heb220	30	550	500	8 d14	No	2676381.75	80.9	1.35
978	0.2	8000	Major	C	450	heb220	30	550	700	8 d25	No	3208188.75	79.8	1.27
979	0.2	8000	Major	S	400	heb260	30	550	500	8 d14	No	3843507.75	72.8	1.29
980	0.2	8000	Major	S	400	heb260	30	550	700	8 d25	No	4466446	73.1	1.24
981	0.2	8000	Minor	C	450	heb220	30	550	500	8 d14	No	1949973.375	78.1	1.47
982	0.2	8000	Minor	C	450	heb220	30	550	700	8 d25	No	2554133.5	86.4	1.32
983	0.2	8000	Minor	S	400	heb260	30	550	500	8 d14	No	2641501.5	82.1	1.40
984	0.2	8000	Minor	S	400	heb260	30	550	700	8 d25	No	3285448.75	86.7	1.29
985	0.2	8000	Major	C	450	heb220	50	355	500	8 d14	No	3241151.75	84.6	1.46
986	0.2	8000	Major	C	450	heb220	50	355	700	8 d25	No	3768689.5	84.1	1.37
987	0.2	8000	Major	S	400	heb260	50	355	500	8 d14	No	4516350	84.0	1.45
988	0.2	8000	Major	S	400	heb260	50	355	700	8 d25	No	5151682.5	82.2	1.37
989	0.2	8000	Minor	C	450	heb220	50	355	500	8 d14	No	2374286.75	73.7	1.53
990	0.2	8000	Minor	C	450	heb220	50	355	700	8 d25	No	3125161.75	87.6	1.38
991	0.2	8000	Minor	S	400	heb260	50	355	500	8 d14	No	3163646	80.3	1.51
992	0.2	8000	Minor	S	400	heb260	50	355	700	8 d25	No	3940137.25	93.5	1.38
993	0.2	8000	Major	C	450	heb220	50	460	500	8 d14	No	3244233.75	84.6	1.40
994	0.2	8000	Major	C	450	heb220	50	460	700	8 d25	No	3780129.25	84.0	1.32
995	0.2	8000	Major	S	400	heb260	50	460	500	8 d14	No	4628533	86.6	1.43
996	0.2	8000	Major	S	400	heb260	50	460	700	8 d25	No	5282393.5	83.0	1.36
997	0.2	8000	Minor	C	450	heb220	50	460	500	8 d14	No	2374286.75	73.7	1.51
998	0.2	8000	Minor	C	450	heb220	50	460	700	8 d25	No	3126100.5	87.6	1.37
999	0.2	8000	Minor	S	400	heb260	50	460	500	8 d14	No	3176428.75	84.6	1.48
1000	0.2	8000	Minor	S	400	heb260	50	460	700	8 d25	No	3998552.75	94.8	1.36
1001	0.2	8000	Major	C	450	heb220	50	550	500	8 d14	No	3244233.75	84.6	1.39

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1002	0.2	8000	Major	C	450	heb220	50	550	700	8 d25	No	3780129.25	84.0	1.31
1003	0.2	8000	Major	S	400	heb260	50	550	500	8 d14	No	4629876	86.6	1.34
1004	0.2	8000	Major	S	400	heb260	50	550	700	8 d25	No	5282500.5	83.0	1.28
1005	0.2	8000	Minor	C	450	heb220	50	550	500	8 d14	No	2374286.75	73.7	1.51
1006	0.2	8000	Minor	C	450	heb220	50	550	700	8 d25	No	3126100.5	87.6	1.36
1007	0.2	8000	Minor	S	400	heb260	50	550	500	8 d14	No	3176428.75	84.6	1.46
1008	0.2	8000	Minor	S	400	heb260	50	550	700	8 d25	No	3998552.75	94.8	1.34
1009	0.2	8000	Major	C	450	heb220	60	355	500	8 d14	No	3470336.5	83.6	1.45
1010	0.2	8000	Major	C	450	heb220	60	355	700	8 d25	No	4020866.75	85.0	1.34
1011	0.2	8000	Major	S	400	heb260	60	355	500	8 d14	No	4812004	85.2	1.47
1012	0.2	8000	Major	S	400	heb260	60	355	700	8 d25	No	5475316.5	84.8	1.36
1013	0.2	8000	Minor	C	450	heb220	60	355	500	8 d14	No	2587952.75	93.8	1.47
1014	0.2	8000	Minor	C	450	heb220	60	355	700	8 d25	No	3334275	88.8	1.33
1015	0.2	8000	Minor	S	400	heb260	60	355	500	8 d14	No	3404407.75	81.0	1.51
1016	0.2	8000	Minor	S	400	heb260	60	355	700	8 d25	No	4230944	96.2	1.36
1017	0.2	8000	Major	C	450	heb220	60	460	500	8 d14	No	3476314.75	85.6	1.36
1018	0.2	8000	Major	C	450	heb220	60	460	700	8 d25	No	4029231.75	84.9	1.27
1019	0.2	8000	Major	S	400	heb260	60	460	500	8 d14	No	4931201	87.9	1.39
1020	0.2	8000	Major	S	400	heb260	60	460	700	8 d25	No	5619674	85.6	1.31
1021	0.2	8000	Minor	C	450	heb220	60	460	500	8 d14	No	2590463	95.8	1.46
1022	0.2	8000	Minor	C	450	heb220	60	460	700	8 d25	No	3335387.25	88.8	1.32
1023	0.2	8000	Minor	S	400	heb260	60	460	500	8 d14	No	3420740.25	87.7	1.46
1024	0.2	8000	Minor	S	400	heb260	60	460	700	8 d25	No	4289741	97.5	1.32
1025	0.2	8000	Major	C	450	heb220	60	550	500	8 d14	No	3476314.75	85.6	1.35
1026	0.2	8000	Major	C	450	heb220	60	550	700	8 d25	No	4029231.75	84.9	1.26
1027	0.2	8000	Major	S	400	heb260	60	550	500	8 d14	No	4931527.5	87.9	1.30
1028	0.2	8000	Major	S	400	heb260	60	550	700	8 d25	No	5620150	85.6	1.23
1029	0.2	8000	Minor	C	450	heb220	60	550	500	8 d14	No	2590463	95.8	1.46
1030	0.2	8000	Minor	C	450	heb220	60	550	700	8 d25	No	3335387.25	88.8	1.32
1031	0.2	8000	Minor	S	400	heb260	60	550	500	8 d14	No	3420740.25	87.7	1.45
1032	0.2	8000	Minor	S	400	heb260	60	550	700	8 d25	No	4289741	97.5	1.31
1033	0.2	8000	Major	C	450	heb220	90	355	500	8 d14	No	4066618.5	94.6	1.44
1034	0.2	8000	Major	C	450	heb220	90	355	700	8 d25	No	4876956	89.3	1.35
1035	0.2	8000	Major	S	400	heb260	90	355	500	8 d14	No	5617032.5	86.1	1.52
1036	0.2	8000	Major	S	400	heb260	90	355	700	8 d25	No	6387892	87.0	1.40
1037	0.2	8000	Minor	C	450	heb220	90	355	500	8 d14	No	3137843.75	96.2	1.49
1038	0.2	8000	Minor	C	450	heb220	90	355	700	8 d25	No	3957776.25	86.6	1.36
1039	0.2	8000	Minor	S	400	heb260	90	355	500	8 d14	No	4088985.75	103.7	1.52
1040	0.2	8000	Minor	S	400	heb260	90	355	700	8 d25	No	5018479.5	96.7	1.39
1041	0.2	8000	Major	C	450	heb220	90	460	500	8 d14	No	4067348	91.3	1.37
1042	0.2	8000	Major	C	450	heb220	90	460	700	8 d25	No	4750146	86.6	1.28
1043	0.2	8000	Major	S	400	heb260	90	460	500	8 d14	No	5749527	91.2	1.41
1044	0.2	8000	Major	S	400	heb260	90	460	700	8 d25	No	6542106	87.9	1.33
1045	0.2	8000	Minor	C	450	heb220	90	460	500	8 d14	No	3139542	98.7	1.48
1046	0.2	8000	Minor	C	450	heb220	90	460	700	8 d25	No	3957776.25	86.6	1.34
1047	0.2	8000	Minor	S	400	heb260	90	460	500	8 d14	No	4154984.5	105.1	1.48
1048	0.2	8000	Minor	S	400	heb260	90	460	700	8 d25	No	5077067.5	96.2	1.36
1049	0.2	8000	Major	C	450	heb220	90	550	500	8 d14	No	4067348	91.3	1.37
1050	0.2	8000	Major	C	450	heb220	90	550	700	8 d25	No	4750146	86.6	1.28
1051	0.2	8000	Major	S	400	heb260	90	550	500	8 d14	No	5749853	91.2	1.33
1052	0.2	8000	Major	S	400	heb260	90	550	700	8 d25	No	6542536.5	87.9	1.25
1053	0.2	8000	Minor	C	450	heb220	90	550	500	8 d14	No	3139542	98.7	1.48
1054	0.2	8000	Minor	C	450	heb220	90	550	700	8 d25	No	3957776.25	86.6	1.34
1055	0.2	8000	Minor	S	400	heb260	90	550	500	8 d14	No	4154984.5	105.1	1.47

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1056	0.2	8000	Minor	S	400	heb260	90	550	700	8 d25	No	5077067.5	96.2	1.35
1057	0.2	10000	Major	C	450	heb220	30	355	500	8 d14	No	2091120.5	111.4	1.40
1058	0.2	10000	Major	C	450	heb220	30	355	700	8 d25	No	2543073.25	124.0	1.31
1059	0.2	10000	Major	S	400	heb260	30	355	500	8 d14	No	3017018.5	121.9	1.38
1060	0.2	10000	Major	S	400	heb260	30	355	700	8 d25	No	3524043.75	120.1	1.30
1061	0.2	10000	Minor	C	450	heb220	30	355	500	8 d14	No	1514077	136.9	1.43
1062	0.2	10000	Minor	C	450	heb220	30	355	700	8 d25	No	1997775.625	125.7	1.31
1063	0.2	10000	Minor	S	400	heb260	30	355	500	8 d14	No	2036970.125	136.8	1.41
1064	0.2	10000	Minor	S	400	heb260	30	355	700	8 d25	No	2552837	131.1	1.30
1065	0.2	10000	Major	C	450	heb220	30	460	500	8 d14	No	2101743.5	136.7	1.32
1066	0.2	10000	Major	C	450	heb220	30	460	700	8 d25	No	2544412	125.5	1.25
1067	0.2	10000	Major	S	400	heb260	30	460	500	8 d14	No	3067395.25	124.3	1.35
1068	0.2	10000	Major	S	400	heb260	30	460	700	8 d25	No	3566394.5	121.2	1.29
1069	0.2	10000	Minor	C	450	heb220	30	460	500	8 d14	No	1514113.25	136.9	1.43
1070	0.2	10000	Minor	C	450	heb220	30	460	700	8 d25	No	1997775.625	125.7	1.30
1071	0.2	10000	Minor	S	400	heb260	30	460	500	8 d14	No	2051166.25	136.4	1.38
1072	0.2	10000	Minor	S	400	heb260	30	460	700	8 d25	No	2568702.25	132.6	1.28
1073	0.2	10000	Major	C	450	heb220	30	550	500	8 d14	No	2101743.5	136.7	1.32
1074	0.2	10000	Major	C	450	heb220	30	550	700	8 d25	No	2544412	125.5	1.25
1075	0.2	10000	Major	S	400	heb260	30	550	500	8 d14	No	3067395.25	124.3	1.26
1076	0.2	10000	Major	S	400	heb260	30	550	700	8 d25	No	3566394.5	121.2	1.21
1077	0.2	10000	Minor	C	450	heb220	30	550	500	8 d14	No	1514113.25	136.9	1.43
1078	0.2	10000	Minor	C	450	heb220	30	550	700	8 d25	No	1997775.625	125.7	1.30
1079	0.2	10000	Minor	S	400	heb260	30	550	500	8 d14	No	2051166.25	136.4	1.38
1080	0.2	10000	Minor	S	400	heb260	30	550	700	8 d25	No	2568702.25	132.6	1.28
1081	0.2	10000	Major	C	450	heb220	50	355	500	8 d14	No	2482746	140.2	1.39
1082	0.2	10000	Major	C	450	heb220	50	355	700	8 d25	No	2980349.5	131.8	1.33
1083	0.2	10000	Major	S	400	heb260	50	355	500	8 d14	No	3531512.5	135.3	1.42
1084	0.2	10000	Major	S	400	heb260	50	355	700	8 d25	No	4062704.25	141.1	1.33
1085	0.2	10000	Minor	C	450	heb220	50	355	500	8 d14	No	1804776.625	146.0	1.45
1086	0.2	10000	Minor	C	450	heb220	50	355	700	8 d25	No	2383947.5	147.5	1.33
1087	0.2	10000	Minor	S	400	heb260	50	355	500	8 d14	No	2403763	141.8	1.46
1088	0.2	10000	Minor	S	400	heb260	50	355	700	8 d25	No	2992392.25	156.4	1.34
1089	0.2	10000	Major	C	450	heb220	50	460	500	8 d14	No	2484970.5	140.2	1.35
1090	0.2	10000	Major	C	450	heb220	50	460	700	8 d25	No	2981766.25	131.8	1.28
1091	0.2	10000	Major	S	400	heb260	50	460	500	8 d14	No	3577698.5	134.8	1.37
1092	0.2	10000	Major	S	400	heb260	50	460	700	8 d25	No	4158892.5	141.8	1.30
1093	0.2	10000	Minor	C	450	heb220	50	460	500	8 d14	No	1804647.625	146.0	1.45
1094	0.2	10000	Minor	C	450	heb220	50	460	700	8 d25	No	2374475.25	139.2	1.33
1095	0.2	10000	Minor	S	400	heb260	50	460	500	8 d14	No	2422393	143.3	1.43
1096	0.2	10000	Minor	S	400	heb260	50	460	700	8 d25	No	3022833	158.5	1.32
1097	0.2	10000	Major	C	450	heb220	50	550	500	8 d14	No	2484970.5	140.2	1.35
1098	0.2	10000	Major	C	450	heb220	50	550	700	8 d25	No	2981766.25	131.8	1.28
1099	0.2	10000	Major	S	400	heb260	50	550	500	8 d14	No	3577698.5	134.8	1.30
1100	0.2	10000	Major	S	400	heb260	50	550	700	8 d25	No	4158939.75	141.8	1.25
1101	0.2	10000	Minor	C	450	heb220	50	550	500	8 d14	No	1804647.625	146.0	1.45
1102	0.2	10000	Minor	C	450	heb220	50	550	700	8 d25	No	2374475.25	139.2	1.33
1103	0.2	10000	Minor	S	400	heb260	50	550	500	8 d14	No	2422393	143.3	1.43
1104	0.2	10000	Minor	S	400	heb260	50	550	700	8 d25	No	3022833	158.5	1.32
1105	0.2	10000	Major	C	450	heb220	60	355	500	8 d14	No	2641071	140.4	1.33
1106	0.2	10000	Major	C	450	heb220	60	355	700	8 d25	No	3136881	132.5	1.27
1107	0.2	10000	Major	S	400	heb260	60	355	500	8 d14	No	3727848	137.6	1.41
1108	0.2	10000	Major	S	400	heb260	60	355	700	8 d25	No	4293439.5	144.4	1.31
1109	0.2	10000	Minor	C	450	heb220	60	355	500	8 d14	No	2403666	76.9	1.42

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1110	0.2	10000	Minor	C	450	heb220	60	355	700	8 d25	No	2551423.25	138.6	1.28
1111	0.2	10000	Minor	S	400	heb260	60	355	500	8 d14	No	2508488	142.9	1.43
1112	0.2	10000	Minor	S	400	heb260	60	355	700	8 d25	No	3188855.25	159.5	1.30
1113	0.2	10000	Major	C	450	heb220	60	460	500	8 d14	No	2642250.75	140.4	1.30
1114	0.2	10000	Major	C	450	heb220	60	460	700	8 d25	No	3138018.25	132.4	1.22
1115	0.2	10000	Major	S	400	heb260	60	460	500	8 d14	No	3790470.25	153.1	1.30
1116	0.2	10000	Major	S	400	heb260	60	460	700	8 d25	No	4394237	146.8	1.24
1117	0.2	10000	Minor	C	450	heb220	60	460	500	8 d14	No	2403666	76.9	1.42
1118	0.2	10000	Minor	C	450	heb220	60	460	700	8 d25	No	2551423.25	138.6	1.27
1119	0.2	10000	Minor	S	400	heb260	60	460	500	8 d14	No	2525763.5	144.5	1.40
1120	0.2	10000	Minor	S	400	heb260	60	460	700	8 d25	No	3221828.75	160.3	1.27
1121	0.2	10000	Major	C	450	heb220	60	550	500	8 d14	No	2642250.75	140.4	1.29
1122	0.2	10000	Major	C	450	heb220	60	550	700	8 d25	No	3138018.25	132.4	1.22
1123	0.2	10000	Major	S	400	heb260	60	550	500	8 d14	No	3791378	153.0	1.25
1124	0.2	10000	Major	S	400	heb260	60	550	700	8 d25	No	4394619.5	146.8	1.19
1125	0.2	10000	Minor	C	450	heb220	60	550	500	8 d14	No	2403666	76.9	1.42
1126	0.2	10000	Minor	C	450	heb220	60	550	700	8 d25	No	2551423.25	138.6	1.27
1127	0.2	10000	Minor	S	400	heb260	60	550	500	8 d14	No	2525763.5	144.5	1.39
1128	0.2	10000	Minor	S	400	heb260	60	550	700	8 d25	No	3221828.75	160.3	1.27
1129	0.2	10000	Major	C	450	heb220	90	355	500	8 d14	No	3102374	101.1	1.32
1130	0.2	10000	Major	C	450	heb220	90	355	700	8 d25	No	3616805.25	146.7	1.24
1131	0.2	10000	Major	S	400	heb260	90	355	500	8 d14	No	4278676.5	100.7	1.43
1132	0.2	10000	Major	S	400	heb260	90	355	700	8 d25	No	4886963	150.7	1.32
1133	0.2	10000	Minor	C	450	heb220	90	355	500	8 d14	No	2742339.5	78.2	1.44
1134	0.2	10000	Minor	C	450	heb220	90	355	700	8 d25	No	3067154	83.5	1.26
1135	0.2	10000	Minor	S	400	heb260	90	355	500	8 d14	No	3556488	83.9	1.46
1136	0.2	10000	Minor	S	400	heb260	90	355	700	8 d25	No	3937310.75	90.0	1.31
1137	0.2	10000	Major	C	450	heb220	90	460	500	8 d14	No	3102374	101.1	1.30
1138	0.2	10000	Major	C	450	heb220	90	460	700	8 d25	No	3620427.5	146.7	1.21
1139	0.2	10000	Major	S	400	heb260	90	460	500	8 d14	No	4315347.5	160.7	1.29
1140	0.2	10000	Major	S	400	heb260	90	460	700	8 d25	No	4965545	151.4	1.23
1141	0.2	10000	Minor	C	450	heb220	90	460	500	8 d14	No	2742339.5	78.2	1.43
1142	0.2	10000	Minor	C	450	heb220	90	460	700	8 d25	No	3067154	83.5	1.27
1143	0.2	10000	Minor	S	400	heb260	90	460	500	8 d14	No	3556488	83.9	1.43
1144	0.2	10000	Minor	S	400	heb260	90	460	700	8 d25	No	3937310.75	90.0	1.28
1145	0.2	10000	Major	C	450	heb220	90	550	500	8 d14	No	3102374	101.1	1.30
1146	0.2	10000	Major	C	450	heb220	90	550	700	8 d25	No	3620427.5	146.7	1.21
1147	0.2	10000	Major	S	400	heb260	90	550	500	8 d14	No	4317064.5	160.7	1.25
1148	0.2	10000	Major	S	400	heb260	90	550	700	8 d25	No	4965687	151.4	1.19
1149	0.2	10000	Minor	C	450	heb220	90	550	500	8 d14	No	2742339.5	78.2	1.43
1150	0.2	10000	Minor	C	450	heb220	90	550	700	8 d25	No	3067154	83.5	1.27
1151	0.2	10000	Minor	S	400	heb260	90	550	500	8 d14	No	3556488	83.9	1.42
1152	0.2	10000	Minor	S	400	heb260	90	550	700	8 d25	No	3937310.75	90.0	1.28
1153	0	4000	Major	C	450	heb220	30	355	500	8 d14	No	8828992	5.2	1.50
1154	0	4000	Major	C	450	heb220	30	355	700	8 d25	No	10065459	5.1	1.36
1155	0	4000	Major	S	400	heb260	30	355	500	8 d14	No	9926259	4.9	1.44
1156	0	4000	Major	S	400	heb260	30	355	700	8 d25	No	11086486	4.5	1.33
1157	0	4000	Minor	C	450	heb220	30	355	500	8 d14	No	8460317	6.4	1.50
1158	0	4000	Minor	C	450	heb220	30	355	700	8 d25	No	9718431	6.1	1.36
1159	0	4000	Minor	S	400	heb260	30	355	500	8 d14	No	9355389	6.7	1.44
1160	0	4000	Minor	S	400	heb260	30	355	700	8 d25	No	10658940	6.4	1.34
1161	0	4000	Major	C	450	heb220	30	460	500	8 d14	No	9210606	4.5	1.47
1162	0	4000	Major	C	450	heb220	30	460	700	8 d25	No	11255368	8.3	1.36
1163	0	4000	Major	S	400	heb260	30	460	500	8 d14	No	10672446	4.0	1.42

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1164	0	4000	Major	S	400	heb260	30	460	700	8 d25	No	12682938	7.2	1.33
1165	0	4000	Minor	C	450	heb220	30	460	500	8 d14	No	9060446	8.8	1.47
1166	0	4000	Minor	C	450	heb220	30	460	700	8 d25	No	10722912	9.5	1.35
1167	0	4000	Minor	S	400	heb260	30	460	500	8 d14	No	10127420	8.1	1.42
1168	0	4000	Minor	S	400	heb260	30	460	700	8 d25	No	11877015	9.2	1.32
1169	0	4000	Major	C	450	heb220	30	550	500	8 d14	No	9755342	6.1	1.40
1170	0	4000	Major	C	450	heb220	30	550	700	8 d25	No	11418431	7.6	1.32
1171	0	4000	Major	S	400	heb260	30	550	500	8 d14	No	11171822	4.9	1.36
1172	0	4000	Major	S	400	heb260	30	550	700	8 d25	No	13166234	7.3	1.29
1173	0	4000	Minor	C	450	heb220	30	550	500	8 d14	No	9101059	8.7	1.42
1174	0	4000	Minor	C	450	heb220	30	550	700	8 d25	No	10816296	9.1	1.31
1175	0	4000	Minor	S	400	heb260	30	550	500	8 d14	No	10258339	7.8	1.36
1176	0	4000	Minor	S	400	heb260	30	550	700	8 d25	No	12063156	8.3	1.28
1177	0	4000	Major	C	450	heb220	50	355	500	8 d14	No	11502377	5.9	1.63
1178	0	4000	Major	C	450	heb220	50	355	700	8 d25	No	12774250	5.4	1.47
1179	0	4000	Major	S	400	heb260	50	355	500	8 d14	No	12533973	5.5	1.57
1180	0	4000	Major	S	400	heb260	50	355	700	8 d25	No	13805314	5.1	1.44
1181	0	4000	Minor	C	450	heb220	50	355	500	8 d14	No	11161881	6.5	1.63
1182	0	4000	Minor	C	450	heb220	50	355	700	8 d25	No	12565233	6.4	1.47
1183	0	4000	Minor	S	400	heb260	50	355	500	8 d14	No	12131782	7.0	1.57
1184	0	4000	Minor	S	400	heb260	50	355	700	8 d25	No	13575845	6.8	1.44
1185	0	4000	Major	C	450	heb220	50	460	500	8 d14	No	12134210	5.0	1.59
1186	0	4000	Major	C	450	heb220	50	460	700	8 d25	No	13636951	5.2	1.46
1187	0	4000	Major	S	400	heb260	50	460	500	8 d14	No	13746367	5.0	1.54
1188	0	4000	Major	S	400	heb260	50	460	700	8 d25	No	15139744	4.7	1.43
1189	0	4000	Minor	C	450	heb220	50	460	500	8 d14	No	11654364	5.9	1.58
1190	0	4000	Minor	C	450	heb220	50	460	700	8 d25	No	13125147	6.1	1.45
1191	0	4000	Minor	S	400	heb260	50	460	500	8 d14	No	12957427	6.7	1.53
1192	0	4000	Minor	S	400	heb260	50	460	700	8 d25	No	14351386	5.9	1.42
1193	0	4000	Major	C	450	heb220	50	550	500	8 d14	No	12342759	5.4	1.52
1194	0	4000	Major	C	450	heb220	50	550	700	8 d25	No	13699970	5.0	1.41
1195	0	4000	Major	S	400	heb260	50	550	500	8 d14	No	13846154	4.5	1.47
1196	0	4000	Major	S	400	heb260	50	550	700	8 d25	No	16168956	6.7	1.38
1197	0	4000	Minor	C	450	heb220	50	550	500	8 d14	No	11665839	5.9	1.50
1198	0	4000	Minor	C	450	heb220	50	550	700	8 d25	No	13166681	6.0	1.39
1199	0	4000	Minor	S	400	heb260	50	550	500	8 d14	No	13049643	6.2	1.46
1200	0	4000	Minor	S	400	heb260	50	550	700	8 d25	No	14644208	6.0	1.37
1201	0	4000	Major	C	450	heb220	60	355	500	8 d14	No	12740595	5.7	1.71
1202	0	4000	Major	C	450	heb220	60	355	700	8 d25	No	14051551	5.4	1.51
1203	0	4000	Major	S	400	heb260	60	355	500	8 d14	No	13768618	5.4	1.66
1204	0	4000	Major	S	400	heb260	60	355	700	8 d25	No	15080112	5.2	1.49
1205	0	4000	Minor	C	450	heb220	60	355	500	8 d14	No	12524963	6.7	1.70
1206	0	4000	Minor	C	450	heb220	60	355	700	8 d25	No	13838904	6.0	1.51
1207	0	4000	Minor	S	400	heb260	60	355	500	8 d14	No	13392328	6.4	1.65
1208	0	4000	Minor	S	400	heb260	60	355	700	8 d25	No	14853840	6.4	1.48
1209	0	4000	Major	C	450	heb220	60	460	500	8 d14	No	13438413	4.9	1.67
1210	0	4000	Major	C	450	heb220	60	460	700	8 d25	No	14795855	4.8	1.50
1211	0	4000	Major	S	400	heb260	60	460	500	8 d14	No	14902942	4.6	1.62
1212	0	4000	Major	S	400	heb260	60	460	700	8 d25	No	16529679	4.9	1.47
1213	0	4000	Minor	C	450	heb220	60	460	500	8 d14	No	13072952	6.5	1.62
1214	0	4000	Minor	C	450	heb220	60	460	700	8 d25	No	14461093	5.9	1.47
1215	0	4000	Minor	S	400	heb260	60	460	500	8 d14	No	14305271	6.3	1.58
1216	0	4000	Minor	S	400	heb260	60	460	700	8 d25	No	15709768	5.9	1.44
1217	0	4000	Major	C	450	heb220	60	550	500	8 d14	No	13664211	5.2	1.55

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1218	0	4000	Major	C	450	heb220	60	550	700	8 d25	No	15060512	5.0	1.42
1219	0	4000	Major	S	400	heb260	60	550	500	8 d14	No	15242408	4.5	1.53
1220	0	4000	Major	S	400	heb260	60	550	700	8 d25	No	16698608	4.3	1.42
1221	0	4000	Minor	C	450	heb220	60	550	500	8 d14	No	13122318	6.2	1.53
1222	0	4000	Minor	C	450	heb220	60	550	700	8 d25	No	14511726	5.7	1.40
1223	0	4000	Minor	S	400	heb260	60	550	500	8 d14	No	14391699	5.8	1.48
1224	0	4000	Minor	S	400	heb260	60	550	700	8 d25	No	16047179	5.9	1.37
1225	0	4000	Major	C	450	heb220	90	355	500	8 d14	No	16658791	5.1	1.82
1226	0	4000	Major	C	450	heb220	90	355	700	8 d25	No	17851378	4.5	1.62
1227	0	4000	Major	S	400	heb260	90	355	500	8 d14	No	17718124	5.2	1.77
1228	0	4000	Major	S	400	heb260	90	355	700	8 d25	No	18949740	4.6	1.60
1229	0	4000	Minor	C	450	heb220	90	355	500	8 d14	No	16412352	5.2	1.82
1230	0	4000	Minor	C	450	heb220	90	355	700	8 d25	No	17820166	5.2	1.61
1231	0	4000	Minor	S	400	heb260	90	355	500	8 d14	No	17461326	6.0	1.77
1232	0	4000	Minor	S	400	heb260	90	355	700	8 d25	No	18667412	5.1	1.60
1233	0	4000	Major	C	450	heb220	90	460	500	8 d14	No	17580764	4.8	1.76
1234	0	4000	Major	C	450	heb220	90	460	700	8 d25	No	18797776	4.4	1.59
1235	0	4000	Major	S	400	heb260	90	460	500	8 d14	No	18911868	4.3	1.74
1236	0	4000	Major	S	400	heb260	90	460	700	8 d25	No	20455766	4.5	1.58
1237	0	4000	Minor	C	450	heb220	90	460	500	8 d14	No	16947152	4.9	1.74
1238	0	4000	Minor	C	450	heb220	90	460	700	8 d25	No	18410772	5.0	1.56
1239	0	4000	Minor	S	400	heb260	90	460	500	8 d14	No	18227556	5.1	1.70
1240	0	4000	Minor	S	400	heb260	90	460	700	8 d25	No	19728138	5.1	1.54
1241	0	4000	Major	C	450	heb220	90	550	500	8 d14	No	17674380	4.5	1.65
1242	0	4000	Major	C	450	heb220	90	550	700	8 d25	No	18879804	4.1	1.51
1243	0	4000	Major	S	400	heb260	90	550	500	8 d14	No	19367716	4.3	1.61
1244	0	4000	Major	S	400	heb260	90	550	700	8 d25	No	20634012	4.0	1.49
1245	0	4000	Minor	C	450	heb220	90	550	500	8 d14	No	17289176	5.3	1.64
1246	0	4000	Minor	C	450	heb220	90	550	700	8 d25	No	18481746	4.8	1.50
1247	0	4000	Minor	S	400	heb260	90	550	500	8 d14	No	18627460	5.2	1.59
1248	0	4000	Minor	S	400	heb260	90	550	700	8 d25	No	19884238	5.5	1.46
1249	0.1	4000	Major	C	450	heb220	30	355	500	8 d14	No	5668047.5	13.1	1.49
1250	0.1	4000	Major	C	450	heb220	30	355	700	8 d25	No	6535119.5	13.7	1.37
1251	0.1	4000	Major	S	400	heb260	30	355	500	8 d14	No	6923435	12.0	1.44
1252	0.1	4000	Major	S	400	heb260	30	355	700	8 d25	No	7794201	12.1	1.34
1253	0.1	4000	Minor	C	450	heb220	30	355	500	8 d14	No	4984854.5	13.7	1.50
1254	0.1	4000	Minor	C	450	heb220	30	355	700	8 d25	No	5914803	14.9	1.37
1255	0.1	4000	Minor	S	400	heb260	30	355	500	8 d14	No	6000512.5	13.5	1.44
1256	0.1	4000	Minor	S	400	heb260	30	355	700	8 d25	No	6988523.5	13.6	1.34
1257	0.1	4000	Major	C	450	heb220	30	460	500	8 d14	No	5723283	13.0	1.47
1258	0.1	4000	Major	C	450	heb220	30	460	700	8 d25	No	6664365	14.5	1.36
1259	0.1	4000	Major	S	400	heb260	30	460	500	8 d14	No	7611148.5	13.9	1.42
1260	0.1	4000	Major	S	400	heb260	30	460	700	8 d25	No	9003861	16.4	1.34
1261	0.1	4000	Minor	C	450	heb220	30	460	500	8 d14	No	5003520.5	13.7	1.45
1262	0.1	4000	Minor	C	450	heb220	30	460	700	8 d25	No	5981659	14.6	1.34
1263	0.1	4000	Minor	S	400	heb260	30	460	500	8 d14	No	6207902	13.9	1.41
1264	0.1	4000	Minor	S	400	heb260	30	460	700	8 d25	No	7228862.5	14.1	1.32
1265	0.1	4000	Major	C	450	heb220	30	550	500	8 d14	No	5723283	13.0	1.38
1266	0.1	4000	Major	C	450	heb220	30	550	700	8 d25	No	6664365	14.5	1.31
1267	0.1	4000	Major	S	400	heb260	30	550	500	8 d14	No	7622557.5	13.9	1.36
1268	0.1	4000	Major	S	400	heb260	30	550	700	8 d25	No	9242196	16.8	1.29
1269	0.1	4000	Minor	C	450	heb220	30	550	500	8 d14	No	5003520.5	13.7	1.43
1270	0.1	4000	Minor	C	450	heb220	30	550	700	8 d25	No	5981659	14.6	1.31
1271	0.1	4000	Minor	S	400	heb260	30	550	500	8 d14	No	6207902	13.9	1.37

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1272	0.1	4000	Minor	S	400	heb260	30	550	700	8 d25	No	7228862.5	14.1	1.28
1273	0.1	4000	Major	C	450	heb220	50	355	500	8 d14	No	7361581.5	14.2	1.59
1274	0.1	4000	Major	C	450	heb220	50	355	700	8 d25	No	8193357.5	14.3	1.44
1275	0.1	4000	Major	S	400	heb260	50	355	500	8 d14	No	8865606	13.9	1.54
1276	0.1	4000	Major	S	400	heb260	50	355	700	8 d25	No	9721397	13.3	1.42
1277	0.1	4000	Minor	C	450	heb220	50	355	500	8 d14	No	6594818	14.6	1.59
1278	0.1	4000	Minor	C	450	heb220	50	355	700	8 d25	No	7594900.5	14.9	1.44
1279	0.1	4000	Minor	S	400	heb260	50	355	500	8 d14	No	7935817	14.8	1.53
1280	0.1	4000	Minor	S	400	heb260	50	355	700	8 d25	No	8902235	14.5	1.42
1281	0.1	4000	Major	C	450	heb220	50	460	500	8 d14	No	7474800	14.0	1.55
1282	0.1	4000	Major	C	450	heb220	50	460	700	8 d25	No	8377536.5	14.0	1.43
1283	0.1	4000	Major	S	400	heb260	50	460	500	8 d14	No	9240250	13.3	1.51
1284	0.1	4000	Major	S	400	heb260	50	460	700	8 d25	No	10256578	13.4	1.41
1285	0.1	4000	Minor	C	450	heb220	50	460	500	8 d14	No	6769329.5	15.2	1.52
1286	0.1	4000	Minor	C	450	heb220	50	460	700	8 d25	No	7663884.5	14.7	1.42
1287	0.1	4000	Minor	S	400	heb260	50	460	500	8 d14	No	8251754	15.2	1.49
1288	0.1	4000	Minor	S	400	heb260	50	460	700	8 d25	No	9256868	14.8	1.40
1289	0.1	4000	Major	C	450	heb220	50	550	500	8 d14	No	7474800	14.0	1.46
1290	0.1	4000	Major	C	450	heb220	50	550	700	8 d25	No	8377536.5	14.0	1.38
1291	0.1	4000	Major	S	400	heb260	50	550	500	8 d14	No	9247634	13.3	1.44
1292	0.1	4000	Major	S	400	heb260	50	550	700	8 d25	No	11111579	16.3	1.37
1293	0.1	4000	Minor	C	450	heb220	50	550	500	8 d14	No	6769329.5	15.2	1.50
1294	0.1	4000	Minor	C	450	heb220	50	550	700	8 d25	No	7663884.5	14.7	1.39
1295	0.1	4000	Minor	S	400	heb260	50	550	500	8 d14	No	8254763.5	15.2	1.45
1296	0.1	4000	Minor	S	400	heb260	50	550	700	8 d25	No	9261950	14.8	1.37
1297	0.1	4000	Major	C	450	heb220	60	355	500	8 d14	No	8016726	13.8	1.63
1298	0.1	4000	Major	C	450	heb220	60	355	700	8 d25	No	8906990	13.9	1.46
1299	0.1	4000	Major	S	400	heb260	60	355	500	8 d14	No	9618135	13.5	1.59
1300	0.1	4000	Major	S	400	heb260	60	355	700	8 d25	No	10608852	13.7	1.45
1301	0.1	4000	Minor	C	450	heb220	60	355	500	8 d14	No	7468284	15.4	1.61
1302	0.1	4000	Minor	C	450	heb220	60	355	700	8 d25	No	8394461	15.1	1.45
1303	0.1	4000	Minor	S	400	heb260	60	355	500	8 d14	No	8799489	14.8	1.58
1304	0.1	4000	Minor	S	400	heb260	60	355	700	8 d25	No	9778347	14.7	1.45
1305	0.1	4000	Major	C	450	heb220	60	460	500	8 d14	No	8280226.5	14.3	1.57
1306	0.1	4000	Major	C	450	heb220	60	460	700	8 d25	No	9037069	13.8	1.44
1307	0.1	4000	Major	S	400	heb260	60	460	500	8 d14	No	10149105	13.6	1.55
1308	0.1	4000	Major	S	400	heb260	60	460	700	8 d25	No	11187574	13.8	1.44
1309	0.1	4000	Minor	C	450	heb220	60	460	500	8 d14	No	7548515	15.2	1.53
1310	0.1	4000	Minor	C	450	heb220	60	460	700	8 d25	No	8478434	14.9	1.41
1311	0.1	4000	Minor	S	400	heb260	60	460	500	8 d14	No	9147698	15.2	1.52
1312	0.1	4000	Minor	S	400	heb260	60	460	700	8 d25	No	10160560	15.1	1.40
1313	0.1	4000	Major	C	450	heb220	60	550	500	8 d14	No	8280226.5	14.3	1.45
1314	0.1	4000	Major	C	450	heb220	60	550	700	8 d25	No	9037069	13.8	1.36
1315	0.1	4000	Major	S	400	heb260	60	550	500	8 d14	No	10171153	13.6	1.45
1316	0.1	4000	Major	S	400	heb260	60	550	700	8 d25	No	11234690	13.6	1.37
1317	0.1	4000	Minor	C	450	heb220	60	550	500	8 d14	No	7548515	15.2	1.50
1318	0.1	4000	Minor	C	450	heb220	60	550	700	8 d25	No	8478434	14.9	1.38
1319	0.1	4000	Minor	S	400	heb260	60	550	500	8 d14	No	9155566	15.2	1.46
1320	0.1	4000	Minor	S	400	heb260	60	550	700	8 d25	No	10176860	15.0	1.36
1321	0.1	4000	Major	C	450	heb220	90	355	500	8 d14	No	10269226	13.9	1.71
1322	0.1	4000	Major	C	450	heb220	90	355	700	8 d25	No	11037272	13.6	1.54
1323	0.1	4000	Major	S	400	heb260	90	355	500	8 d14	No	12137220	13.7	1.69
1324	0.1	4000	Major	S	400	heb260	90	355	700	8 d25	No	13015416	13.4	1.54
1325	0.1	4000	Minor	C	450	heb220	90	355	500	8 d14	No	9564641	14.1	1.70

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1326	0.1	4000	Minor	C	450	heb220	90	355	700	8 d25	No	10524596	14.2	1.53
1327	0.1	4000	Minor	S	400	heb260	90	355	500	8 d14	No	11277828	14.6	1.68
1328	0.1	4000	Minor	S	400	heb260	90	355	700	8 d25	No	12357137	14.6	1.54
1329	0.1	4000	Major	C	450	heb220	90	460	500	8 d14	No	10427303	13.8	1.64
1330	0.1	4000	Major	C	450	heb220	90	460	700	8 d25	No	11191322	13.4	1.51
1331	0.1	4000	Major	S	400	heb260	90	460	500	8 d14	No	12576022	13.3	1.65
1332	0.1	4000	Major	S	400	heb260	90	460	700	8 d25	No	13703222	13.5	1.52
1333	0.1	4000	Minor	C	450	heb220	90	460	500	8 d14	No	9845878	14.8	1.61
1334	0.1	4000	Minor	C	450	heb220	90	460	700	8 d25	No	10614867	14.1	1.48
1335	0.1	4000	Minor	S	400	heb260	90	460	500	8 d14	No	11525569	14.3	1.61
1336	0.1	4000	Minor	S	400	heb260	90	460	700	8 d25	No	12612530	14.4	1.48
1337	0.1	4000	Major	C	450	heb220	90	550	500	8 d14	No	10427303	13.8	1.54
1338	0.1	4000	Major	C	450	heb220	90	550	700	8 d25	No	11191322	13.4	1.43
1339	0.1	4000	Major	S	400	heb260	90	550	500	8 d14	No	12607112	13.2	1.53
1340	0.1	4000	Major	S	400	heb260	90	550	700	8 d25	No	13750214	13.4	1.43
1341	0.1	4000	Minor	C	450	heb220	90	550	500	8 d14	No	9845878	14.8	1.58
1342	0.1	4000	Minor	C	450	heb220	90	550	700	8 d25	No	10614867	14.1	1.45
1343	0.1	4000	Minor	S	400	heb260	90	550	500	8 d14	No	11758428	14.9	1.55
1344	0.1	4000	Minor	S	400	heb260	90	550	700	8 d25	No	12633486	14.3	1.43
1345	0.2	4000	Major	C	450	heb220	30	355	500	8 d14	No	3929128.75	18.3	1.49
1346	0.2	4000	Major	C	450	heb220	30	355	700	8 d25	No	4625170.5	19.5	1.37
1347	0.2	4000	Major	S	400	heb260	30	355	500	8 d14	No	5214892	15.3	1.44
1348	0.2	4000	Major	S	400	heb260	30	355	700	8 d25	No	5996453	15.8	1.34
1349	0.2	4000	Minor	C	450	heb220	30	355	500	8 d14	No	3135002.5	19.1	1.49
1350	0.2	4000	Minor	C	450	heb220	30	355	700	8 d25	No	3906049.5	19.3	1.36
1351	0.2	4000	Minor	S	400	heb260	30	355	500	8 d14	No	4094656.5	18.3	1.44
1352	0.2	4000	Minor	S	400	heb260	30	355	700	8 d25	No	4989596.5	18.5	1.34
1353	0.2	4000	Major	C	450	heb220	30	460	500	8 d14	No	3957274	18.2	1.46
1354	0.2	4000	Major	C	450	heb220	30	460	700	8 d25	No	4681534.5	19.4	1.36
1355	0.2	4000	Major	S	400	heb260	30	460	500	8 d14	No	5808088.5	19.0	1.42
1356	0.2	4000	Major	S	400	heb260	30	460	700	8 d25	No	6948673.5	21.3	1.34
1357	0.2	4000	Minor	C	450	heb220	30	460	500	8 d14	No	3135763.25	19.1	1.45
1358	0.2	4000	Minor	C	450	heb220	30	460	700	8 d25	No	3932903.75	20.2	1.34
1359	0.2	4000	Minor	S	400	heb260	30	460	500	8 d14	No	4201390	18.9	1.41
1360	0.2	4000	Minor	S	400	heb260	30	460	700	8 d25	No	5113552.5	19.2	1.32
1361	0.2	4000	Major	C	450	heb220	30	550	500	8 d14	No	3957274	18.2	1.37
1362	0.2	4000	Major	C	450	heb220	30	550	700	8 d25	No	4708974.5	31.3	1.29
1363	0.2	4000	Major	S	400	heb260	30	550	500	8 d14	No	5815899	19.0	1.36
1364	0.2	4000	Major	S	400	heb260	30	550	700	8 d25	No	7102529	21.8	1.29
1365	0.2	4000	Minor	C	450	heb220	30	550	500	8 d14	No	3135763.25	19.1	1.43
1366	0.2	4000	Minor	C	450	heb220	30	550	700	8 d25	No	3932903.75	20.2	1.32
1367	0.2	4000	Minor	S	400	heb260	30	550	500	8 d14	No	4201390	18.9	1.37
1368	0.2	4000	Minor	S	400	heb260	30	550	700	8 d25	No	5113552.5	19.2	1.28
1369	0.2	4000	Major	C	450	heb220	50	355	500	8 d14	No	4952013	18.7	1.56
1370	0.2	4000	Major	C	450	heb220	50	355	700	8 d25	No	5653616	18.3	1.44
1371	0.2	4000	Major	S	400	heb260	50	355	500	8 d14	No	6638146	17.7	1.52
1372	0.2	4000	Major	S	400	heb260	50	355	700	8 d25	No	7435418	17.5	1.42
1373	0.2	4000	Minor	C	450	heb220	50	355	500	8 d14	No	4101261.25	20.3	1.54
1374	0.2	4000	Minor	C	450	heb220	50	355	700	8 d25	No	4922942	19.6	1.43
1375	0.2	4000	Minor	S	400	heb260	50	355	500	8 d14	No	5407318.5	20.9	1.51
1376	0.2	4000	Minor	S	400	heb260	50	355	700	8 d25	No	6315073	20.4	1.42
1377	0.2	4000	Major	C	450	heb220	50	460	500	8 d14	No	4978392	18.7	1.52
1378	0.2	4000	Major	C	450	heb220	50	460	700	8 d25	No	5762632	18.9	1.43
1379	0.2	4000	Major	S	400	heb260	50	460	500	8 d14	No	6948082.5	18.1	1.49

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1380	0.2	4000	Major	S	400	heb260	50	460	700	8 d25	No	7673237.5	17.3	1.41
1381	0.2	4000	Minor	C	450	heb220	50	460	500	8 d14	No	4105958.5	20.3	1.51
1382	0.2	4000	Minor	C	450	heb220	50	460	700	8 d25	No	4936532	19.5	1.41
1383	0.2	4000	Minor	S	400	heb260	50	460	500	8 d14	No	5506089.5	20.6	1.49
1384	0.2	4000	Minor	S	400	heb260	50	460	700	8 d25	No	6474054.5	20.0	1.40
1385	0.2	4000	Major	C	450	heb220	50	550	500	8 d14	No	4978392	18.7	1.45
1386	0.2	4000	Major	C	450	heb220	50	550	700	8 d25	No	5762632	18.9	1.37
1387	0.2	4000	Major	S	400	heb260	50	550	500	8 d14	No	6952113	18.1	1.44
1388	0.2	4000	Major	S	400	heb260	50	550	700	8 d25	No	7673864.5	17.3	1.37
1389	0.2	4000	Minor	C	450	heb220	50	550	500	8 d14	No	4105958.5	20.3	1.50
1390	0.2	4000	Minor	C	450	heb220	50	550	700	8 d25	No	4936532	19.5	1.39
1391	0.2	4000	Minor	S	400	heb260	50	550	500	8 d14	No	5506089.5	20.6	1.45
1392	0.2	4000	Minor	S	400	heb260	50	550	700	8 d25	No	6474054.5	20.0	1.36
1393	0.2	4000	Major	C	450	heb220	60	355	500	8 d14	No	5464896.5	19.4	1.58
1394	0.2	4000	Major	C	450	heb220	60	355	700	8 d25	No	6185201.5	18.9	1.44
1395	0.2	4000	Major	S	400	heb260	60	355	500	8 d14	No	7245994	18.4	1.56
1396	0.2	4000	Major	S	400	heb260	60	355	700	8 d25	No	7975462.5	17.5	1.44
1397	0.2	4000	Minor	C	450	heb220	60	355	500	8 d14	No	4571553.5	20.9	1.55
1398	0.2	4000	Minor	C	450	heb220	60	355	700	8 d25	No	5417225.5	20.3	1.43
1399	0.2	4000	Minor	S	400	heb260	60	355	500	8 d14	No	5987959.5	21.5	1.55
1400	0.2	4000	Minor	S	400	heb260	60	355	700	8 d25	No	6888993	20.0	1.43
1401	0.2	4000	Major	C	450	heb220	60	460	500	8 d14	No	5503187.5	19.3	1.53
1402	0.2	4000	Major	C	450	heb220	60	460	700	8 d25	No	6229758.5	18.9	1.42
1403	0.2	4000	Major	S	400	heb260	60	460	500	8 d14	No	7496711.5	18.1	1.53
1404	0.2	4000	Major	S	400	heb260	60	460	700	8 d25	No	8355388	17.9	1.43
1405	0.2	4000	Minor	C	450	heb220	60	460	500	8 d14	No	4583620.5	20.9	1.51
1406	0.2	4000	Minor	C	450	heb220	60	460	700	8 d25	No	5440889	20.2	1.39
1407	0.2	4000	Minor	S	400	heb260	60	460	500	8 d14	No	6112889	21.1	1.50
1408	0.2	4000	Minor	S	400	heb260	60	460	700	8 d25	No	7065468	20.7	1.39
1409	0.2	4000	Major	C	450	heb220	60	550	500	8 d14	No	5503187.5	19.3	1.44
1410	0.2	4000	Major	C	450	heb220	60	550	700	8 d25	No	6229758.5	18.9	1.34
1411	0.2	4000	Major	S	400	heb260	60	550	500	8 d14	No	7498209	18.1	1.44
1412	0.2	4000	Major	S	400	heb260	60	550	700	8 d25	No	8362151.5	17.9	1.35
1413	0.2	4000	Minor	C	450	heb220	60	550	500	8 d14	No	4583620.5	20.9	1.49
1414	0.2	4000	Minor	C	450	heb220	60	550	700	8 d25	No	5440889	20.2	1.37
1415	0.2	4000	Minor	S	400	heb260	60	550	500	8 d14	No	6112889	21.1	1.45
1416	0.2	4000	Minor	S	400	heb260	60	550	700	8 d25	No	7073693	20.7	1.35
1417	0.2	4000	Major	C	450	heb220	90	355	500	8 d14	No	6715478	19.0	1.66
1418	0.2	4000	Major	C	450	heb220	90	355	700	8 d25	No	7488564.5	18.7	1.52
1419	0.2	4000	Major	S	400	heb260	90	355	500	8 d14	No	8834886	18.0	1.66
1420	0.2	4000	Major	S	400	heb260	90	355	700	8 d25	No	9701274	17.9	1.53
1421	0.2	4000	Minor	C	450	heb220	90	355	500	8 d14	No	5865655	21.0	1.64
1422	0.2	4000	Minor	C	450	heb220	90	355	700	8 d25	No	6686943.5	19.7	1.51
1423	0.2	4000	Minor	S	400	heb260	90	355	500	8 d14	No	7550165.5	20.1	1.65
1424	0.2	4000	Minor	S	400	heb260	90	355	700	8 d25	No	8593028	20.0	1.52
1425	0.2	4000	Major	C	450	heb220	90	460	500	8 d14	No	6750846.5	19.0	1.60
1426	0.2	4000	Major	C	450	heb220	90	460	700	8 d25	No	7532433.5	18.6	1.48
1427	0.2	4000	Major	S	400	heb260	90	460	500	8 d14	No	9263934	18.3	1.62
1428	0.2	4000	Major	S	400	heb260	90	460	700	8 d25	No	9985234	17.7	1.50
1429	0.2	4000	Minor	C	450	heb220	90	460	500	8 d14	No	5892382.5	20.8	1.58
1430	0.2	4000	Minor	C	450	heb220	90	460	700	8 d25	No	6706893.5	19.6	1.46
1431	0.2	4000	Minor	S	400	heb260	90	460	500	8 d14	No	7776342	20.9	1.58
1432	0.2	4000	Minor	S	400	heb260	90	460	700	8 d25	No	8722254	19.8	1.46
1433	0.2	4000	Major	C	450	heb220	90	550	500	8 d14	No	6750846.5	19.0	1.51

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1434	0.2	4000	Major	C	450	heb220	90	550	700	8 d25	No	7532433.5	18.6	1.41
1435	0.2	4000	Major	S	400	heb260	90	550	500	8 d14	No	9269555	18.3	1.51
1436	0.2	4000	Major	S	400	heb260	90	550	700	8 d25	No	9989597	17.7	1.41
1437	0.2	4000	Minor	C	450	heb220	90	550	500	8 d14	No	5892382.5	20.8	1.56
1438	0.2	4000	Minor	C	450	heb220	90	550	700	8 d25	No	6706893.5	19.6	1.43
1439	0.2	4000	Minor	S	400	heb260	90	550	500	8 d14	No	7776342	20.9	1.53
1440	0.2	4000	Minor	S	400	heb260	90	550	700	8 d25	No	8722254	19.8	1.42
1441	0	3000	Major	C	450	heb220	30	355	500	8 d14	Yes	8844541	11.5	1.49
1442	0	3000	Major	C	450	heb220	30	355	700	8 d25	Yes	11189040	9.6	1.38
1443	0	3000	Minor	C	450	heb220	30	355	500	8 d14	Yes	8885521	12.0	1.49
1444	0	3000	Minor	C	450	heb220	30	355	700	8 d25	Yes	11191789	9.6	1.38
1445	0	3000	Major	C	450	heb220	30	460	500	8 d14	Yes	9917418	11.8	1.47
1446	0	3000	Major	C	450	heb220	30	460	700	8 d25	Yes	12226504	9.9	1.37
1447	0	3000	Minor	C	450	heb220	30	460	500	8 d14	Yes	9864357	12.9	1.47
1448	0	3000	Minor	C	450	heb220	30	460	700	8 d25	Yes	12214986	10.2	1.37
1449	0	3000	Major	C	450	heb220	30	550	500	8 d14	Yes	10533165	10.6	1.40
1450	0	3000	Major	C	450	heb220	30	550	700	8 d25	Yes	12837689	9.9	1.33
1451	0	3000	Minor	C	450	heb220	30	550	500	8 d14	Yes	10411354	12.6	1.40
1452	0	3000	Minor	C	450	heb220	30	550	700	8 d25	Yes	12758303	10.7	1.33
1453	0	3000	Major	C	450	heb220	60	355	500	8 d14	Yes	12872503	7.2	1.70
1454	0	3000	Major	C	450	heb220	60	355	700	8 d25	Yes	15203121	6.4	1.57
1455	0	3000	Minor	C	450	heb220	60	355	500	8 d14	Yes	12866267	7.2	1.71
1456	0	3000	Minor	C	450	heb220	60	355	700	8 d25	Yes	15204091	6.3	1.58
1457	0	3000	Major	C	450	heb220	60	460	500	8 d14	Yes	13870986	7.5	1.65
1458	0	3000	Major	C	450	heb220	60	460	700	8 d25	Yes	16194924	6.4	1.55
1459	0	3000	Minor	C	450	heb220	60	460	500	8 d14	Yes	13939323	8.2	1.65
1460	0	3000	Minor	C	450	heb220	60	460	700	8 d25	Yes	16286210	6.9	1.55
1461	0	3000	Major	C	450	heb220	60	550	500	8 d14	Yes	14509732	8.0	1.58
1462	0	3000	Major	C	450	heb220	60	550	700	8 d25	Yes	16822202	6.5	1.50
1463	0	3000	Minor	C	450	heb220	60	550	500	8 d14	Yes	14489728	8.4	1.58
1464	0	3000	Minor	C	450	heb220	60	550	700	8 d25	Yes	16819802	6.9	1.50
1465	0	3000	Major	C	450	heb220	90	355	500	8 d14	Yes	15174081	4.3	1.84
1466	0	3000	Major	C	450	heb220	90	355	700	8 d25	Yes	19112932	3.8	1.71
1467	0	3000	Minor	C	450	heb220	90	355	500	8 d14	Yes	15529872	4.5	1.84
1468	0	3000	Minor	C	450	heb220	90	355	700	8 d25	Yes	19068240	4.0	1.71
1469	0	3000	Major	C	450	heb220	90	460	500	8 d14	Yes	16458478	4.6	1.79
1470	0	3000	Major	C	450	heb220	90	460	700	8 d25	Yes	20210474	4.1	1.67
1471	0	3000	Minor	C	450	heb220	90	460	500	8 d14	Yes	16498278	4.4	1.79
1472	0	3000	Minor	C	450	heb220	90	460	700	8 d25	Yes	20191304	4.1	1.67
1473	0	3000	Major	C	450	heb220	90	550	500	8 d14	Yes	17337740	4.5	1.72
1474	0	3000	Major	C	450	heb220	90	550	700	8 d25	Yes	20894702	4.4	1.62
1475	0	3000	Minor	C	450	heb220	90	550	500	8 d14	Yes	17509956	4.8	1.72
1476	0	3000	Minor	C	450	heb220	90	550	700	8 d25	Yes	20877254	4.6	1.62
1477	0	6000	Major	C	450	heb220	30	355	500	8 d14	Yes	6657344	37.7	1.45
1478	0	6000	Major	C	450	heb220	30	355	700	8 d25	Yes	8108260.5	38.6	1.35
1479	0	6000	Minor	C	450	heb220	30	355	500	8 d14	Yes	6201034	39.1	1.45
1480	0	6000	Minor	C	450	heb220	30	355	700	8 d25	Yes	7211235	49.2	1.33
1481	0	6000	Major	C	450	heb220	30	460	500	8 d14	Yes	7192003	32.9	1.44
1482	0	6000	Major	C	450	heb220	30	460	700	8 d25	Yes	8680608	36.9	1.34
1483	0	6000	Minor	C	450	heb220	30	460	500	8 d14	Yes	6039166	44.6	1.44
1484	0	6000	Minor	C	450	heb220	30	460	700	8 d25	Yes	7702392.5	44.6	1.33
1485	0	6000	Major	C	450	heb220	30	550	500	8 d14	Yes	7487014	36.7	1.38
1486	0	6000	Major	C	450	heb220	30	550	700	8 d25	Yes	9156742	38.0	1.31
1487	0	6000	Minor	C	450	heb220	30	550	500	8 d14	Yes	6149217.5	46.2	1.39

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1488	0	6000	Minor	C	450	heb220	30	550	700	8 d25	Yes	7897308	48.0	1.30
1489	0	6000	Major	C	450	heb220	60	355	500	8 d14	Yes	9334029	36.3	1.52
1490	0	6000	Major	C	450	heb220	60	355	700	8 d25	Yes	10366107	43.7	1.41
1491	0	6000	Minor	C	450	heb220	60	355	500	8 d14	Yes	8884181	47.2	1.51
1492	0	6000	Minor	C	450	heb220	60	355	700	8 d25	Yes	10016827	46.4	1.40
1493	0	6000	Major	C	450	heb220	60	460	500	8 d14	Yes	9841805	32.3	1.51
1494	0	6000	Major	C	450	heb220	60	460	700	8 d25	Yes	11455264	36.9	1.41
1495	0	6000	Minor	C	450	heb220	60	460	500	8 d14	Yes	8859808	40.8	1.50
1496	0	6000	Minor	C	450	heb220	60	460	700	8 d25	Yes	10500104	47.4	1.39
1497	0	6000	Major	C	450	heb220	60	550	500	8 d14	Yes	10227844	38.5	1.46
1498	0	6000	Major	C	450	heb220	60	550	700	8 d25	Yes	11967160	38.9	1.37
1499	0	6000	Minor	C	450	heb220	60	550	500	8 d14	Yes	9032806	41.8	1.46
1500	0	6000	Minor	C	450	heb220	60	550	700	8 d25	Yes	10732352	44.7	1.36
1501	0	6000	Major	C	450	heb220	90	355	500	8 d14	Yes	11442696	35.1	1.58
1502	0	6000	Major	C	450	heb220	90	355	700	8 d25	Yes	13336385	41.8	1.47
1503	0	6000	Minor	C	450	heb220	90	355	500	8 d14	Yes	10796350	43.8	1.59
1504	0	6000	Minor	C	450	heb220	90	355	700	8 d25	Yes	13063662	43.2	1.47
1505	0	6000	Major	C	450	heb220	90	460	500	8 d14	Yes	12110034	35.4	1.57
1506	0	6000	Major	C	450	heb220	90	460	700	8 d25	Yes	14493555	36.3	1.47
1507	0	6000	Minor	C	450	heb220	90	460	500	8 d14	Yes	11391884	43.9	1.56
1508	0	6000	Minor	C	450	heb220	90	460	700	8 d25	Yes	13617882	41.9	1.45
1509	0	6000	Major	C	450	heb220	90	550	500	8 d14	Yes	12729068	36.7	1.52
1510	0	6000	Major	C	450	heb220	90	550	700	8 d25	Yes	15048498	36.5	1.44
1511	0	6000	Minor	C	450	heb220	90	550	500	8 d14	Yes	11680654	43.7	1.52
1512	0	6000	Minor	C	450	heb220	90	550	700	8 d25	Yes	13889395	42.4	1.42
1513	0	8000	Major	C	450	heb220	30	355	500	8 d14	Yes	4880576.5	52.1	1.44
1514	0	8000	Major	C	450	heb220	30	355	700	8 d25	Yes	5782629.5	52.0	1.33
1515	0	8000	Minor	C	450	heb220	30	355	500	8 d14	Yes	4133227.25	55.8	1.45
1516	0	8000	Minor	C	450	heb220	30	355	700	8 d25	Yes	5034695.5	55.3	1.33
1517	0	8000	Major	C	450	heb220	30	460	500	8 d14	Yes	5086706	63.8	1.42
1518	0	8000	Major	C	450	heb220	30	460	700	8 d25	Yes	6088561	71.6	1.32
1519	0	8000	Minor	C	450	heb220	30	460	500	8 d14	Yes	4195130	59.7	1.43
1520	0	8000	Minor	C	450	heb220	30	460	700	8 d25	Yes	5128309.5	62.9	1.32
1521	0	8000	Major	C	450	heb220	30	550	500	8 d14	Yes	5103094	67.6	1.37
1522	0	8000	Major	C	450	heb220	30	550	700	8 d25	Yes	6136508	77.9	1.29
1523	0	8000	Minor	C	450	heb220	30	550	500	8 d14	Yes	4195130	59.7	1.39
1524	0	8000	Minor	C	450	heb220	30	550	700	8 d25	Yes	5129317.5	62.9	1.28
1525	0	8000	Major	C	450	heb220	60	355	500	8 d14	Yes	6632550	53.3	1.50
1526	0	8000	Major	C	450	heb220	60	355	700	8 d25	Yes	7571663.5	58.0	1.39
1527	0	8000	Minor	C	450	heb220	60	355	500	8 d14	Yes	5868580	57.6	1.50
1528	0	8000	Minor	C	450	heb220	60	355	700	8 d25	Yes	6806243	60.3	1.38
1529	0	8000	Major	C	450	heb220	60	460	500	8 d14	Yes	6922238.5	67.9	1.46
1530	0	8000	Major	C	450	heb220	60	460	700	8 d25	Yes	7969014.5	70.0	1.37
1531	0	8000	Minor	C	450	heb220	60	460	500	8 d14	Yes	5966098	60.9	1.48
1532	0	8000	Minor	C	450	heb220	60	460	700	8 d25	Yes	6938961	62.9	1.36
1533	0	8000	Major	C	450	heb220	60	550	500	8 d14	Yes	6956273.5	71.5	1.41
1534	0	8000	Major	C	450	heb220	60	550	700	8 d25	Yes	8034801.5	76.1	1.34
1535	0	8000	Minor	C	450	heb220	60	550	500	8 d14	Yes	5968876	65.5	1.44
1536	0	8000	Minor	C	450	heb220	60	550	700	8 d25	Yes	6947250	67.2	1.33
1537	0	8000	Major	C	450	heb220	90	355	500	8 d14	Yes	8094600	56.3	1.54
1538	0	8000	Major	C	450	heb220	90	355	700	8 d25	Yes	9435832	62.7	1.43
1539	0	8000	Minor	C	450	heb220	90	355	500	8 d14	Yes	7451494.5	73.1	1.53
1540	0	8000	Minor	C	450	heb220	90	355	700	8 d25	Yes	8653862	67.2	1.41
1541	0	8000	Major	C	450	heb220	90	460	500	8 d14	Yes	8580131	63.6	1.52

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1542	0	8000	Major	C	450	heb220	90	460	700	8 d25	Yes	9948970	70.7	1.41
1543	0	8000	Minor	C	450	heb220	90	460	500	8 d14	Yes	7682741	69.1	1.52
1544	0	8000	Minor	C	450	heb220	90	460	700	8 d25	Yes	8869783	72.8	1.38
1545	0	8000	Major	C	450	heb220	90	550	500	8 d14	Yes	8657774	77.3	1.44
1546	0	8000	Major	C	450	heb220	90	550	700	8 d25	Yes	10027566	73.5	1.37
1547	0	8000	Minor	C	450	heb220	90	550	500	8 d14	Yes	7705239	69.0	1.49
1548	0	8000	Minor	C	450	heb220	90	550	700	8 d25	Yes	8892622	72.7	1.36
1549	0	10000	Major	C	450	heb220	30	355	500	8 d14	Yes	3716426.5	73.3	1.43
1550	0	10000	Major	C	450	heb220	30	355	700	8 d25	Yes	4364354.5	70.7	1.32
1551	0	10000	Minor	C	450	heb220	30	355	500	8 d14	Yes	3083359.75	70.9	1.44
1552	0	10000	Minor	C	450	heb220	30	355	700	8 d25	Yes	3724685.75	73.2	1.32
1553	0	10000	Major	C	450	heb220	30	460	500	8 d14	Yes	3736809.5	73.1	1.41
1554	0	10000	Major	C	450	heb220	30	460	700	8 d25	Yes	4389646.5	74.9	1.32
1555	0	10000	Minor	C	450	heb220	30	460	500	8 d14	Yes	3087818.75	75.9	1.42
1556	0	10000	Minor	C	450	heb220	30	460	700	8 d25	Yes	3730501.75	73.2	1.31
1557	0	10000	Major	C	450	heb220	30	550	500	8 d14	Yes	3736809.5	73.1	1.36
1558	0	10000	Major	C	450	heb220	30	550	700	8 d25	Yes	4389646.5	74.9	1.29
1559	0	10000	Minor	C	450	heb220	30	550	500	8 d14	Yes	3087818.75	75.9	1.39
1560	0	10000	Minor	C	450	heb220	30	550	700	8 d25	Yes	3730501.75	73.2	1.28
1561	0	10000	Major	C	450	heb220	60	355	500	8 d14	Yes	4926447.5	75.5	1.46
1562	0	10000	Major	C	450	heb220	60	355	700	8 d25	Yes	5587388	74.2	1.37
1563	0	10000	Minor	C	450	heb220	60	355	500	8 d14	Yes	4251486	75.6	1.48
1564	0	10000	Minor	C	450	heb220	60	355	700	8 d25	Yes	4918211	80.3	1.35
1565	0	10000	Major	C	450	heb220	60	460	500	8 d14	Yes	4951888	80.1	1.44
1566	0	10000	Major	C	450	heb220	60	460	700	8 d25	Yes	5617130	78.5	1.36
1567	0	10000	Minor	C	450	heb220	60	460	500	8 d14	Yes	4257890	80.8	1.45
1568	0	10000	Minor	C	450	heb220	60	460	700	8 d25	Yes	4933826	80.2	1.34
1569	0	10000	Major	C	450	heb220	60	550	500	8 d14	Yes	4951888	80.1	1.40
1570	0	10000	Major	C	450	heb220	60	550	700	8 d25	Yes	5617130	78.5	1.33
1571	0	10000	Minor	C	450	heb220	60	550	500	8 d14	Yes	4257890	80.8	1.42
1572	0	10000	Minor	C	450	heb220	60	550	700	8 d25	Yes	4933826	80.2	1.31
1573	0	10000	Major	C	450	heb220	90	355	500	8 d14	Yes	5850011	76.5	1.50
1574	0	10000	Major	C	450	heb220	90	355	700	8 d25	Yes	6659325	80.9	1.39
1575	0	10000	Minor	C	450	heb220	90	355	500	8 d14	Yes	5218702.5	76.0	1.52
1576	0	10000	Minor	C	450	heb220	90	355	700	8 d25	Yes	5933009	85.1	1.37
1577	0	10000	Major	C	450	heb220	90	460	500	8 d14	Yes	5888074	76.3	1.48
1578	0	10000	Major	C	450	heb220	90	460	700	8 d25	Yes	6699671	85.2	1.38
1579	0	10000	Minor	C	450	heb220	90	460	500	8 d14	Yes	5224276.5	92.3	1.47
1580	0	10000	Minor	C	450	heb220	90	460	700	8 d25	Yes	5948791	85.0	1.35
1581	0	10000	Major	C	450	heb220	90	550	500	8 d14	Yes	5888074	76.3	1.44
1582	0	10000	Major	C	450	heb220	90	550	700	8 d25	Yes	6699671	85.2	1.35
1583	0	10000	Minor	C	450	heb220	90	550	500	8 d14	Yes	5224276.5	92.3	1.44
1584	0	10000	Minor	C	450	heb220	90	550	700	8 d25	Yes	5948791	85.0	1.32
1585	0	3000	Major	S	400	heb260	30	355	500	8 d14	Yes	9664973	12.5	1.44
1586	0	3000	Major	S	400	heb260	30	355	700	8 d25	Yes	11997677	8.8	1.35
1587	0	3000	Minor	S	400	heb260	30	355	500	8 d14	Yes	9644334	12.8	1.44
1588	0	3000	Minor	S	400	heb260	30	355	700	8 d25	Yes	11991078	10.2	1.35
1589	0	3000	Major	S	400	heb260	30	460	500	8 d14	Yes	11087854	11.4	1.42
1590	0	3000	Major	S	400	heb260	30	460	700	8 d25	Yes	13376402	9.1	1.34
1591	0	3000	Minor	S	400	heb260	30	460	500	8 d14	Yes	10931945	14.1	1.42
1592	0	3000	Minor	S	400	heb260	30	460	700	8 d25	Yes	13325946	11.4	1.34
1593	0	3000	Major	S	400	heb260	30	550	500	8 d14	Yes	11935441	11.5	1.36
1594	0	3000	Major	S	400	heb260	30	550	700	8 d25	Yes	14191882	9.6	1.30
1595	0	3000	Minor	S	400	heb260	30	550	500	8 d14	Yes	11682182	13.0	1.36

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1596	0	3000	Minor	S	400	heb260	30	550	700	8 d25	Yes	14052769	11.9	1.30
1597	0	3000	Major	S	400	heb260	60	355	500	8 d14	Yes	13770089	8.1	1.64
1598	0	3000	Major	S	400	heb260	60	355	700	8 d25	Yes	16113408	6.9	1.53
1599	0	3000	Minor	S	400	heb260	60	355	500	8 d14	Yes	13750538	8.1	1.64
1600	0	3000	Minor	S	400	heb260	60	355	700	8 d25	Yes	16088161	7.1	1.53
1601	0	3000	Major	S	400	heb260	60	460	500	8 d14	Yes	15128679	8.1	1.59
1602	0	3000	Major	S	400	heb260	60	460	700	8 d25	Yes	17460294	7.0	1.51
1603	0	3000	Minor	S	400	heb260	60	460	500	8 d14	Yes	15100264	8.8	1.59
1604	0	3000	Minor	S	400	heb260	60	460	700	8 d25	Yes	17452508	7.1	1.51
1605	0	3000	Major	S	400	heb260	60	550	500	8 d14	Yes	15982018	8.3	1.52
1606	0	3000	Major	S	400	heb260	60	550	700	8 d25	Yes	18268242	7.0	1.46
1607	0	3000	Minor	S	400	heb260	60	550	500	8 d14	Yes	15807941	9.2	1.52
1608	0	3000	Minor	S	400	heb260	60	550	700	8 d25	Yes	18243104	7.9	1.45
1609	0	3000	Major	S	400	heb260	90	355	500	8 d14	Yes	17780518	4.8	1.78
1610	0	3000	Major	S	400	heb260	90	355	700	8 d25	Yes	20081720	4.3	1.67
1611	0	3000	Minor	S	400	heb260	90	355	500	8 d14	Yes	17734358	4.9	1.79
1612	0	3000	Minor	S	400	heb260	90	355	700	8 d25	Yes	20033172	4.5	1.67
1613	0	3000	Major	S	400	heb260	90	460	500	8 d14	Yes	19247770	5.5	1.72
1614	0	3000	Major	S	400	heb260	90	460	700	8 d25	Yes	21542172	4.6	1.63
1615	0	3000	Minor	S	400	heb260	90	460	500	8 d14	Yes	19073440	5.1	1.73
1616	0	3000	Minor	S	400	heb260	90	460	700	8 d25	Yes	21496010	4.8	1.63
1617	0	3000	Major	S	400	heb260	90	550	500	8 d14	Yes	20103830	5.4	1.65
1618	0	3000	Major	S	400	heb260	90	550	700	8 d25	Yes	22403158	4.8	1.57
1619	0	3000	Minor	S	400	heb260	90	550	500	8 d14	Yes	19943912	5.7	1.66
1620	0	3000	Minor	S	400	heb260	90	550	700	8 d25	Yes	22218938	4.6	1.58
1621	0	6000	Major	S	400	heb260	30	355	500	8 d14	Yes	7634762	30.5	1.42
1622	0	6000	Major	S	400	heb260	30	355	700	8 d25	Yes	9071059	32.7	1.33
1623	0	6000	Minor	S	400	heb260	30	355	500	8 d14	Yes	6952147	38.1	1.42
1624	0	6000	Minor	S	400	heb260	30	355	700	8 d25	Yes	8416607	42.6	1.32
1625	0	6000	Major	S	400	heb260	30	460	500	8 d14	Yes	8628048	25.7	1.41
1626	0	6000	Major	S	400	heb260	30	460	700	8 d25	Yes	10148101	30.3	1.33
1627	0	6000	Minor	S	400	heb260	30	460	500	8 d14	Yes	7011512	41.0	1.41
1628	0	6000	Minor	S	400	heb260	30	460	700	8 d25	Yes	8702444	43.2	1.32
1629	0	6000	Major	S	400	heb260	30	550	500	8 d14	Yes	9216194	29.2	1.35
1630	0	6000	Major	S	400	heb260	30	550	700	8 d25	Yes	10910443	29.7	1.29
1631	0	6000	Minor	S	400	heb260	30	550	500	8 d14	Yes	7235625	43.9	1.35
1632	0	6000	Minor	S	400	heb260	30	550	700	8 d25	Yes	9026209	44.6	1.28
1633	0	6000	Major	S	400	heb260	60	355	500	8 d14	Yes	10272272	31.2	1.52
1634	0	6000	Major	S	400	heb260	60	355	700	8 d25	Yes	11871539	37.9	1.41
1635	0	6000	Minor	S	400	heb260	60	355	500	8 d14	Yes	9617133	42.0	1.52
1636	0	6000	Minor	S	400	heb260	60	355	700	8 d25	Yes	10848739	49.0	1.42
1637	0	6000	Major	S	400	heb260	60	460	500	8 d14	Yes	12048623	31.1	1.50
1638	0	6000	Major	S	400	heb260	60	460	700	8 d25	Yes	12943329	32.6	1.41
1639	0	6000	Minor	S	400	heb260	60	460	500	8 d14	Yes	9835942	37.2	1.51
1640	0	6000	Minor	S	400	heb260	60	460	700	8 d25	Yes	11565814	43.3	1.41
1641	0	6000	Major	S	400	heb260	60	550	500	8 d14	Yes	11978538	29.8	1.44
1642	0	6000	Major	S	400	heb260	60	550	700	8 d25	Yes	13743950	31.3	1.38
1643	0	6000	Minor	S	400	heb260	60	550	500	8 d14	Yes	10132259	39.7	1.45
1644	0	6000	Minor	S	400	heb260	60	550	700	8 d25	Yes	11929443	42.2	1.37
1645	0	6000	Major	S	400	heb260	90	355	500	8 d14	Yes	13112727	37.9	1.58
1646	0	6000	Major	S	400	heb260	90	355	700	8 d25	Yes	14439084	40.9	1.49
1647	0	6000	Minor	S	400	heb260	90	355	500	8 d14	Yes	12041801	42.3	1.60
1648	0	6000	Minor	S	400	heb260	90	355	700	8 d25	Yes	13981024	45.3	1.49
1649	0	6000	Major	S	400	heb260	90	460	500	8 d14	Yes	14183222	31.6	1.58

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1650	0	6000	Major	S	400	heb260	90	460	700	8 d25	Yes	15973917	33.9	1.49
1651	0	6000	Minor	S	400	heb260	90	460	500	8 d14	Yes	12863702	40.4	1.57
1652	0	6000	Minor	S	400	heb260	90	460	700	8 d25	Yes	14788304	43.1	1.47
1653	0	6000	Major	S	400	heb260	90	550	500	8 d14	Yes	14994036	31.3	1.52
1654	0	6000	Major	S	400	heb260	90	550	700	8 d25	Yes	16872024	33.0	1.45
1655	0	6000	Minor	S	400	heb260	90	550	500	8 d14	Yes	13244304	39.3	1.52
1656	0	6000	Minor	S	400	heb260	90	550	700	8 d25	Yes	15168538	42.8	1.43
1657	0	8000	Major	S	400	heb260	30	355	500	8 d14	Yes	5947421	42.5	1.41
1658	0	8000	Major	S	400	heb260	30	355	700	8 d25	Yes	7748061	49.9	1.33
1659	0	8000	Minor	S	400	heb260	30	355	500	8 d14	Yes	4745519.5	49.8	1.41
1660	0	8000	Minor	S	400	heb260	30	355	700	8 d25	Yes	5709016	52.9	1.32
1661	0	8000	Major	S	400	heb260	30	460	500	8 d14	Yes	6512515	60.4	1.39
1662	0	8000	Major	S	400	heb260	30	460	700	8 d25	Yes	7654119.5	63.2	1.32
1663	0	8000	Minor	S	400	heb260	30	460	500	8 d14	Yes	4873605.5	60.9	1.39
1664	0	8000	Minor	S	400	heb260	30	460	700	8 d25	Yes	5891953	62.6	1.31
1665	0	8000	Major	S	400	heb260	30	550	500	8 d14	Yes	6663467.5	69.5	1.33
1666	0	8000	Major	S	400	heb260	30	550	700	8 d25	Yes	7898057.5	72.6	1.28
1667	0	8000	Minor	S	400	heb260	30	550	500	8 d14	Yes	4880162.5	60.9	1.35
1668	0	8000	Minor	S	400	heb260	30	550	700	8 d25	Yes	5910163	66.6	1.27
1669	0	8000	Major	S	400	heb260	60	355	500	8 d14	Yes	8694425	49.7	1.50
1670	0	8000	Major	S	400	heb260	60	355	700	8 d25	Yes	9772876	57.2	1.41
1671	0	8000	Minor	S	400	heb260	60	355	500	8 d14	Yes	6520974.5	56.4	1.51
1672	0	8000	Minor	S	400	heb260	60	355	700	8 d25	Yes	7510633	58.5	1.41
1673	0	8000	Major	S	400	heb260	60	460	500	8 d14	Yes	8433116	61.4	1.47
1674	0	8000	Major	S	400	heb260	60	460	700	8 d25	Yes	9585966	63.2	1.39
1675	0	8000	Minor	S	400	heb260	60	460	500	8 d14	Yes	6731867	62.0	1.47
1676	0	8000	Minor	S	400	heb260	60	460	700	8 d25	Yes	7796553	70.6	1.37
1677	0	8000	Major	S	400	heb260	60	550	500	8 d14	Yes	8616862	70.6	1.41
1678	0	8000	Major	S	400	heb260	60	550	700	8 d25	Yes	9854132	73.3	1.34
1679	0	8000	Minor	S	400	heb260	60	550	500	8 d14	Yes	6754840	66.2	1.43
1680	0	8000	Minor	S	400	heb260	60	550	700	8 d25	Yes	7840378.5	70.2	1.34
1681	0	8000	Major	S	400	heb260	90	355	500	8 d14	Yes	10663239	57.7	1.57
1682	0	8000	Major	S	400	heb260	90	355	700	8 d25	Yes	10577233	54.8	1.47
1683	0	8000	Minor	S	400	heb260	90	355	500	8 d14	Yes	8335307	66.6	1.57
1684	0	8000	Minor	S	400	heb260	90	355	700	8 d25	Yes	9419872	68.9	1.46
1685	0	8000	Major	S	400	heb260	90	460	500	8 d14	Yes	10422454	60.5	1.53
1686	0	8000	Major	S	400	heb260	90	460	700	8 d25	Yes	11571912	61.3	1.45
1687	0	8000	Minor	S	400	heb260	90	460	500	8 d14	Yes	8698836	69.5	1.53
1688	0	8000	Minor	S	400	heb260	90	460	700	8 d25	Yes	9850874	74.8	1.42
1689	0	8000	Major	S	400	heb260	90	550	500	8 d14	Yes	10632250	67.3	1.47
1690	0	8000	Major	S	400	heb260	90	550	700	8 d25	Yes	11868605	75.2	1.40
1691	0	8000	Minor	S	400	heb260	90	550	500	8 d14	Yes	8749802	73.4	1.49
1692	0	8000	Minor	S	400	heb260	90	550	700	8 d25	Yes	9926266	73.9	1.39
1693	0	10000	Major	S	400	heb260	30	355	500	8 d14	Yes	4668490.5	67.2	1.40
1694	0	10000	Major	S	400	heb260	30	355	700	8 d25	Yes	5363176.5	66.3	1.32
1695	0	10000	Minor	S	400	heb260	30	355	500	8 d14	Yes	3534416.25	70.1	1.41
1696	0	10000	Minor	S	400	heb260	30	355	700	8 d25	Yes	4231117	71.2	1.31
1697	0	10000	Major	S	400	heb260	30	460	500	8 d14	Yes	4754308	74.3	1.39
1698	0	10000	Major	S	400	heb260	30	460	700	8 d25	Yes	5468310	76.9	1.31
1699	0	10000	Minor	S	400	heb260	30	460	500	8 d14	Yes	3551410.5	74.8	1.38
1700	0	10000	Minor	S	400	heb260	30	460	700	8 d25	Yes	4254189.5	75.6	1.31
1701	0	10000	Major	S	400	heb260	30	550	500	8 d14	Yes	4754308	74.3	1.33
1702	0	10000	Major	S	400	heb260	30	550	700	8 d25	Yes	5468282.5	76.9	1.28
1703	0	10000	Minor	S	400	heb260	30	550	500	8 d14	Yes	3551410.5	74.8	1.34

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1704	0	10000	Minor	S	400	heb260	30	550	700	8 d25	Yes	4254189.5	75.6	1.26
1705	0	10000	Major	S	400	heb260	60	355	500	8 d14	Yes	5912900.5	69.1	1.48
1706	0	10000	Major	S	400	heb260	60	355	700	8 d25	Yes	6626957.5	68.3	1.39
1707	0	10000	Minor	S	400	heb260	60	355	500	8 d14	Yes	4769042	78.6	1.48
1708	0	10000	Minor	S	400	heb260	60	355	700	8 d25	Yes	5479970	77.4	1.38
1709	0	10000	Major	S	400	heb260	60	460	500	8 d14	Yes	6015737.5	80.5	1.45
1710	0	10000	Major	S	400	heb260	60	460	700	8 d25	Yes	6750582	83.3	1.37
1711	0	10000	Minor	S	400	heb260	60	460	500	8 d14	Yes	4794843	78.4	1.46
1712	0	10000	Minor	S	400	heb260	60	460	700	8 d25	Yes	5514380	82.0	1.36
1713	0	10000	Major	S	400	heb260	60	550	500	8 d14	Yes	6016036.5	80.5	1.40
1714	0	10000	Major	S	400	heb260	60	550	700	8 d25	Yes	6751617	83.3	1.34
1715	0	10000	Minor	S	400	heb260	60	550	500	8 d14	Yes	4794843	78.4	1.42
1716	0	10000	Minor	S	400	heb260	60	550	700	8 d25	Yes	5514380	82.0	1.33
1717	0	10000	Major	S	400	heb260	90	355	500	8 d14	Yes	7029090.5	75.7	1.53
1718	0	10000	Major	S	400	heb260	90	355	700	8 d25	Yes	7772069.5	79.0	1.44
1719	0	10000	Minor	S	400	heb260	90	355	500	8 d14	Yes	5840976	85.6	1.53
1720	0	10000	Minor	S	400	heb260	90	355	700	8 d25	Yes	6587909	80.4	1.43
1721	0	10000	Major	S	400	heb260	90	460	500	8 d14	Yes	7194404	86.5	1.49
1722	0	10000	Major	S	400	heb260	90	460	700	8 d25	Yes	7954091	93.4	1.41
1723	0	10000	Minor	S	400	heb260	90	460	500	8 d14	Yes	5882457.5	85.2	1.50
1724	0	10000	Minor	S	400	heb260	90	460	700	8 d25	Yes	6636357.5	84.9	1.41
1725	0	10000	Major	S	400	heb260	90	550	500	8 d14	Yes	7195184	86.5	1.44
1726	0	10000	Major	S	400	heb260	90	550	700	8 d25	Yes	7961020	93.3	1.37
1727	0	10000	Minor	S	400	heb260	90	550	500	8 d14	Yes	5882457.5	85.2	1.47
1728	0	10000	Minor	S	400	heb260	90	550	700	8 d25	Yes	6636357.5	84.9	1.38
1729	0.1	3000	Major	C	450	heb220	30	355	500	8 d14	Yes	5878620	20.0	1.49
1730	0.1	3000	Major	C	450	heb220	30	355	700	8 d25	Yes	7452971.5	19.4	1.37
1731	0.1	3000	Major	S	400	heb260	30	355	500	8 d14	Yes	7051224	18.9	1.44
1732	0.1	3000	Major	S	400	heb260	30	355	700	8 d25	Yes	8672328	18.2	1.34
1733	0.1	3000	Minor	C	450	heb220	30	355	500	8 d14	Yes	5349500	22.8	1.49
1734	0.1	3000	Minor	C	450	heb220	30	355	700	8 d25	Yes	7165260	21.4	1.37
1735	0.1	3000	Minor	S	400	heb260	30	355	500	8 d14	Yes	6490284	23.2	1.42
1736	0.1	3000	Minor	S	400	heb260	30	355	700	8 d25	Yes	8358501	21.2	1.34
1737	0.1	3000	Major	C	450	heb220	30	460	500	8 d14	Yes	6622923	19.4	1.46
1738	0.1	3000	Major	C	450	heb220	30	460	700	8 d25	Yes	8191197	19.1	1.37
1739	0.1	3000	Major	S	400	heb260	30	460	500	8 d14	Yes	8147439	18.7	1.42
1740	0.1	3000	Major	S	400	heb260	30	460	700	8 d25	Yes	9779202	18.1	1.34
1741	0.1	3000	Minor	C	450	heb220	30	460	500	8 d14	Yes	5726232.5	23.7	1.45
1742	0.1	3000	Minor	C	450	heb220	30	460	700	8 d25	Yes	7591004.5	21.5	1.36
1743	0.1	3000	Minor	S	400	heb260	30	460	500	8 d14	Yes	7152690.5	23.8	1.41
1744	0.1	3000	Minor	S	400	heb260	30	460	700	8 d25	Yes	9101553	22.1	1.33
1745	0.1	3000	Major	C	450	heb220	30	550	500	8 d14	Yes	7031630	19.5	1.40
1746	0.1	3000	Major	C	450	heb220	30	550	700	8 d25	Yes	8593484	18.6	1.32
1747	0.1	3000	Major	S	400	heb260	30	550	500	8 d14	Yes	8719548	18.1	1.35
1748	0.1	3000	Major	S	400	heb260	30	550	700	8 d25	Yes	10356649	17.6	1.30
1749	0.1	3000	Minor	C	450	heb220	30	550	500	8 d14	Yes	5895602.5	23.3	1.39
1750	0.1	3000	Minor	C	450	heb220	30	550	700	8 d25	Yes	7788544.5	22.4	1.31
1751	0.1	3000	Minor	S	400	heb260	30	550	500	8 d14	Yes	7452505.5	23.2	1.35
1752	0.1	3000	Minor	S	400	heb260	30	550	700	8 d25	Yes	9408721	21.8	1.29
1753	0.1	3000	Major	C	450	heb220	60	355	500	8 d14	Yes	8275854.5	15.9	1.62
1754	0.1	3000	Major	C	450	heb220	60	355	700	8 d25	Yes	9899151	15.9	1.50
1755	0.1	3000	Major	S	400	heb260	60	355	500	8 d14	Yes	9759178	15.8	1.58
1756	0.1	3000	Major	S	400	heb260	60	355	700	8 d25	Yes	11366260	15.7	1.47
1757	0.1	3000	Minor	C	450	heb220	60	355	500	8 d14	Yes	7807874	17.6	1.61

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1758	0.1	3000	Minor	C	450	heb220	60	355	700	8 d25	Yes	9536182	16.4	1.50
1759	0.1	3000	Minor	S	400	heb260	60	355	500	8 d14	Yes	9247245	17.8	1.57
1760	0.1	3000	Minor	S	400	heb260	60	355	700	8 d25	Yes	11047392	16.9	1.47
1761	0.1	3000	Major	C	450	heb220	60	460	500	8 d14	Yes	9023673	15.4	1.58
1762	0.1	3000	Major	C	450	heb220	60	460	700	8 d25	Yes	10643378	15.6	1.48
1763	0.1	3000	Major	S	400	heb260	60	460	500	8 d14	Yes	10814442	15.3	1.55
1764	0.1	3000	Major	S	400	heb260	60	460	700	8 d25	Yes	12448089	15.1	1.46
1765	0.1	3000	Minor	C	450	heb220	60	460	500	8 d14	Yes	8181864	17.4	1.57
1766	0.1	3000	Minor	C	450	heb220	60	460	700	8 d25	Yes	10001268	17.3	1.47
1767	0.1	3000	Minor	S	400	heb260	60	460	500	8 d14	Yes	9898608	17.5	1.53
1768	0.1	3000	Minor	S	400	heb260	60	460	700	8 d25	Yes	11754423	16.8	1.45
1769	0.1	3000	Major	C	450	heb220	60	550	500	8 d14	Yes	9473760	15.6	1.52
1770	0.1	3000	Major	C	450	heb220	60	550	700	8 d25	Yes	11039089	15.2	1.44
1771	0.1	3000	Major	S	400	heb260	60	550	500	8 d14	Yes	11449317	15.4	1.48
1772	0.1	3000	Major	S	400	heb260	60	550	700	8 d25	Yes	13025488	14.7	1.41
1773	0.1	3000	Minor	C	450	heb220	60	550	500	8 d14	Yes	8330034	17.2	1.51
1774	0.1	3000	Minor	C	450	heb220	60	550	700	8 d25	Yes	10191852	17.1	1.42
1775	0.1	3000	Minor	S	400	heb260	60	550	500	8 d14	Yes	10262723	17.9	1.46
1776	0.1	3000	Minor	S	400	heb260	60	550	700	8 d25	Yes	12047724	16.6	1.40
1777	0.1	3000	Major	C	450	heb220	90	355	500	8 d14	Yes	9747838	12.5	1.73
1778	0.1	3000	Major	C	450	heb220	90	355	700	8 d25	Yes	12121825	13.3	1.60
1779	0.1	3000	Major	S	400	heb260	90	355	500	8 d14	Yes	12198977	13.4	1.69
1780	0.1	3000	Major	S	400	heb260	90	355	700	8 d25	Yes	13734784	12.8	1.59
1781	0.1	3000	Minor	C	450	heb220	90	355	500	8 d14	Yes	9816061	13.9	1.72
1782	0.1	3000	Minor	C	450	heb220	90	355	700	8 d25	Yes	11803865	13.6	1.60
1783	0.1	3000	Minor	S	400	heb260	90	355	500	8 d14	Yes	11907456	14.8	1.69
1784	0.1	3000	Minor	S	400	heb260	90	355	700	8 d25	Yes	13653639	14.0	1.58
1785	0.1	3000	Major	C	450	heb220	90	460	500	8 d14	Yes	10928038	12.8	1.68
1786	0.1	3000	Major	C	450	heb220	90	460	700	8 d25	Yes	12903828	13.0	1.58
1787	0.1	3000	Major	S	400	heb260	90	460	500	8 d14	Yes	13312961	12.9	1.66
1788	0.1	3000	Major	S	400	heb260	90	460	700	8 d25	Yes	14988161	12.8	1.56
1789	0.1	3000	Minor	C	450	heb220	90	460	500	8 d14	Yes	10198665	13.8	1.68
1790	0.1	3000	Minor	C	450	heb220	90	460	700	8 d25	Yes	12200739	13.6	1.57
1791	0.1	3000	Minor	S	400	heb260	90	460	500	8 d14	Yes	12609788	14.5	1.65
1792	0.1	3000	Minor	S	400	heb260	90	460	700	8 d25	Yes	14343652	13.9	1.55
1793	0.1	3000	Major	C	450	heb220	90	550	500	8 d14	Yes	11469321	12.9	1.63
1794	0.1	3000	Major	C	450	heb220	90	550	700	8 d25	Yes	13256716	12.7	1.54
1795	0.1	3000	Major	S	400	heb260	90	550	500	8 d14	Yes	13892686	12.5	1.60
1796	0.1	3000	Major	S	400	heb260	90	550	700	8 d25	Yes	15578587	12.4	1.51
1797	0.1	3000	Minor	C	450	heb220	90	550	500	8 d14	Yes	10512000	14.2	1.61
1798	0.1	3000	Minor	C	450	heb220	90	550	700	8 d25	Yes	12344917	13.6	1.53
1799	0.1	3000	Minor	S	400	heb260	90	550	500	8 d14	Yes	12856336	14.3	1.58
1800	0.1	3000	Minor	S	400	heb260	90	550	700	8 d25	Yes	14606064	13.8	1.51
1801	0.1	6000	Major	C	450	heb220	30	355	500	8 d14	Yes	3980627.5	51.2	1.44
1802	0.1	6000	Major	C	450	heb220	30	355	700	8 d25	Yes	5091589	67.8	1.33
1803	0.1	6000	Major	S	400	heb260	30	355	500	8 d14	Yes	5095692	40.7	1.41
1804	0.1	6000	Major	S	400	heb260	30	355	700	8 d25	Yes	6294395.5	56.3	1.32
1805	0.1	6000	Minor	C	450	heb220	30	355	500	8 d14	Yes	2970885.75	62.2	1.44
1806	0.1	6000	Minor	C	450	heb220	30	355	700	8 d25	Yes	4265952	77.6	1.32
1807	0.1	6000	Minor	S	400	heb260	30	355	500	8 d14	Yes	3757149	62.7	1.41
1808	0.1	6000	Minor	S	400	heb260	30	355	700	8 d25	Yes	5170504.5	75.1	1.31
1809	0.1	6000	Major	C	450	heb220	30	460	500	8 d14	Yes	4437347	68.3	1.42
1810	0.1	6000	Major	C	450	heb220	30	460	700	8 d25	Yes	5599522	67.2	1.33
1811	0.1	6000	Major	S	400	heb260	30	460	500	8 d14	Yes	5890760	52.1	1.40

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1812	0.1	6000	Major	S	400	heb260	30	460	700	8 d25	Yes	7130635.5	54.4	1.33
1813	0.1	6000	Minor	C	450	heb220	30	460	500	8 d14	Yes	3103251.25	67.4	1.43
1814	0.1	6000	Minor	C	450	heb220	30	460	700	8 d25	Yes	4425213.5	77.2	1.31
1815	0.1	6000	Minor	S	400	heb260	30	460	500	8 d14	Yes	4035162.5	57.7	1.40
1816	0.1	6000	Minor	S	400	heb260	30	460	700	8 d25	Yes	5479131.5	73.9	1.31
1817	0.1	6000	Major	C	450	heb220	30	550	500	8 d14	Yes	4627808	73.1	1.37
1818	0.1	6000	Major	C	450	heb220	30	550	700	8 d25	Yes	5819787.5	71.8	1.29
1819	0.1	6000	Major	S	400	heb260	30	550	500	8 d14	Yes	6268765.5	57.0	1.34
1820	0.1	6000	Major	S	400	heb260	30	550	700	8 d25	Yes	7563054	57.6	1.28
1821	0.1	6000	Minor	C	450	heb220	30	550	500	8 d14	Yes	3130732.25	71.4	1.39
1822	0.1	6000	Minor	C	450	heb220	30	550	700	8 d25	Yes	4493074.5	92.9	1.28
1823	0.1	6000	Minor	S	400	heb260	30	550	500	8 d14	Yes	4122076	61.2	1.35
1824	0.1	6000	Minor	S	400	heb260	30	550	700	8 d25	Yes	5594599.5	75.2	1.27
1825	0.1	6000	Major	C	450	heb220	60	355	500	8 d14	Yes	5458656	52.5	1.50
1826	0.1	6000	Major	C	450	heb220	60	355	700	8 d25	Yes	6653741	69.6	1.38
1827	0.1	6000	Major	S	400	heb260	60	355	500	8 d14	Yes	6796887.5	63.2	1.49
1828	0.1	6000	Major	S	400	heb260	60	355	700	8 d25	Yes	8079192.5	57.0	1.41
1829	0.1	6000	Minor	C	450	heb220	60	355	500	8 d14	Yes	4374763	55.4	1.51
1830	0.1	6000	Minor	C	450	heb220	60	355	700	8 d25	Yes	5693873.5	72.8	1.37
1831	0.1	6000	Minor	S	400	heb260	60	355	500	8 d14	Yes	5383540.5	55.1	1.51
1832	0.1	6000	Minor	S	400	heb260	60	355	700	8 d25	Yes	6815663.5	72.9	1.39
1833	0.1	6000	Major	C	450	heb220	60	460	500	8 d14	Yes	5934721	68.7	1.46
1834	0.1	6000	Major	C	450	heb220	60	460	700	8 d25	Yes	7164277.5	67.8	1.38
1835	0.1	6000	Major	S	400	heb260	60	460	500	8 d14	Yes	7661678	54.0	1.48
1836	0.1	6000	Major	S	400	heb260	60	460	700	8 d25	Yes	8938223	55.5	1.40
1837	0.1	6000	Minor	C	450	heb220	60	460	500	8 d14	Yes	4507603.5	59.2	1.48
1838	0.1	6000	Minor	C	450	heb220	60	460	700	8 d25	Yes	5852211.5	72.3	1.35
1839	0.1	6000	Minor	S	400	heb260	60	460	500	8 d14	Yes	5674526	57.6	1.48
1840	0.1	6000	Minor	S	400	heb260	60	460	700	8 d25	Yes	7136507	69.7	1.37
1841	0.1	6000	Major	C	450	heb220	60	550	500	8 d14	Yes	6130165	70.7	1.42
1842	0.1	6000	Major	C	450	heb220	60	550	700	8 d25	Yes	7369488	70.0	1.34
1843	0.1	6000	Major	S	400	heb260	60	550	500	8 d14	Yes	8026009	56.8	1.42
1844	0.1	6000	Major	S	400	heb260	60	550	700	8 d25	Yes	9368120	58.0	1.36
1845	0.1	6000	Minor	C	450	heb220	60	550	500	8 d14	Yes	4520574.5	61.8	1.45
1846	0.1	6000	Minor	C	450	heb220	60	550	700	8 d25	Yes	5915121.5	71.8	1.33
1847	0.1	6000	Minor	S	400	heb260	60	550	500	8 d14	Yes	5762066.5	59.2	1.44
1848	0.1	6000	Minor	S	400	heb260	60	550	700	8 d25	Yes	7256729.5	71.0	1.34
1849	0.1	6000	Major	C	450	heb220	90	355	500	8 d14	Yes	6927853	61.7	1.54
1850	0.1	6000	Major	C	450	heb220	90	355	700	8 d25	Yes	8198577	62.9	1.44
1851	0.1	6000	Major	S	400	heb260	90	355	500	8 d14	Yes	8515779	62.5	1.56
1852	0.1	6000	Major	S	400	heb260	90	355	700	8 d25	Yes	9888554	57.7	1.47
1853	0.1	6000	Minor	C	450	heb220	90	355	500	8 d14	Yes	5801749.5	65.0	1.55
1854	0.1	6000	Minor	C	450	heb220	90	355	700	8 d25	Yes	7213375	64.4	1.43
1855	0.1	6000	Minor	S	400	heb260	90	355	500	8 d14	Yes	7114326.5	55.5	1.59
1856	0.1	6000	Minor	S	400	heb260	90	355	700	8 d25	Yes	8548316	64.2	1.47
1857	0.1	6000	Major	C	450	heb220	90	460	500	8 d14	Yes	7447244.5	63.1	1.52
1858	0.1	6000	Major	C	450	heb220	90	460	700	8 d25	Yes	8715760	61.1	1.43
1859	0.1	6000	Major	S	400	heb260	90	460	500	8 d14	Yes	9473322	54.4	1.55
1860	0.1	6000	Major	S	400	heb260	90	460	700	8 d25	Yes	10841524	54.4	1.46
1861	0.1	6000	Minor	C	450	heb220	90	460	500	8 d14	Yes	5944394.5	63.8	1.53
1862	0.1	6000	Minor	C	450	heb220	90	460	700	8 d25	Yes	7369772.5	66.3	1.40
1863	0.1	6000	Minor	S	400	heb260	90	460	500	8 d14	Yes	7400901.5	56.4	1.56
1864	0.1	6000	Minor	S	400	heb260	90	460	700	8 d25	Yes	8881147	65.2	1.44
1865	0.1	6000	Major	C	450	heb220	90	550	500	8 d14	Yes	7587639.5	64.3	1.48

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1866	0.1	6000	Major	C	450	heb220	90	550	700	8 d25	Yes	8888616	62.1	1.40
1867	0.1	6000	Major	S	400	heb260	90	550	500	8 d14	Yes	9871286	57.9	1.49
1868	0.1	6000	Major	S	400	heb260	90	550	700	8 d25	Yes	11262446	57.8	1.42
1869	0.1	6000	Minor	C	450	heb220	90	550	500	8 d14	Yes	5978302.5	66.4	1.49
1870	0.1	6000	Minor	C	450	heb220	90	550	700	8 d25	Yes	7427154	65.8	1.38
1871	0.1	6000	Minor	S	400	heb260	90	550	500	8 d14	Yes	7503423.5	58.2	1.52
1872	0.1	6000	Minor	S	400	heb260	90	550	700	8 d25	Yes	9014226	64.2	1.41
1873	0.1	8000	Major	C	450	heb220	30	355	500	8 d14	Yes	2986239.75	95.7	1.42
1874	0.1	8000	Major	C	450	heb220	30	355	700	8 d25	Yes	3760776.5	118.8	1.31
1875	0.1	8000	Major	S	400	heb260	30	355	500	8 d14	Yes	4025522	70.1	1.40
1876	0.1	8000	Major	S	400	heb260	30	355	700	8 d25	Yes	4831913	96.4	1.31
1877	0.1	8000	Minor	C	450	heb220	30	355	500	8 d14	Yes	2087118.375	121.6	1.42
1878	0.1	8000	Minor	C	450	heb220	30	355	700	8 d25	Yes	2961530.5	136.6	1.29
1879	0.1	8000	Minor	S	400	heb260	30	355	500	8 d14	Yes	2714175	118.4	1.39
1880	0.1	8000	Minor	S	400	heb260	30	355	700	8 d25	Yes	3657511	137.7	1.29
1881	0.1	8000	Major	C	450	heb220	30	460	500	8 d14	Yes	3166101	130.9	1.39
1882	0.1	8000	Major	C	450	heb220	30	460	700	8 d25	Yes	4059970	120.8	1.31
1883	0.1	8000	Major	S	400	heb260	30	460	500	8 d14	Yes	4488130	93.8	1.38
1884	0.1	8000	Major	S	400	heb260	30	460	700	8 d25	Yes	5405863.5	98.4	1.31
1885	0.1	8000	Minor	C	450	heb220	30	460	500	8 d14	Yes	2152917	120.6	1.40
1886	0.1	8000	Minor	C	450	heb220	30	460	700	8 d25	Yes	3042250	137.8	1.28
1887	0.1	8000	Minor	S	400	heb260	30	460	500	8 d14	Yes	2834118.5	115.6	1.38
1888	0.1	8000	Minor	S	400	heb260	30	460	700	8 d25	Yes	3827019.5	136.1	1.28
1889	0.1	8000	Major	C	450	heb220	30	550	500	8 d14	Yes	3238416	131.4	1.34
1890	0.1	8000	Major	C	450	heb220	30	550	700	8 d25	Yes	4155098.75	136.5	1.27
1891	0.1	8000	Major	S	400	heb260	30	550	500	8 d14	Yes	4638604	100.4	1.32
1892	0.1	8000	Major	S	400	heb260	30	550	700	8 d25	Yes	5643923	115.4	1.27
1893	0.1	8000	Minor	C	450	heb220	30	550	500	8 d14	Yes	2156116.25	120.5	1.37
1894	0.1	8000	Minor	C	450	heb220	30	550	700	8 d25	Yes	3067326.25	137.6	1.26
1895	0.1	8000	Minor	S	400	heb260	30	550	500	8 d14	Yes	2883813.5	116.8	1.34
1896	0.1	8000	Minor	S	400	heb260	30	550	700	8 d25	Yes	3878171.5	137.2	1.26
1897	0.1	8000	Major	C	450	heb220	60	355	500	8 d14	Yes	3934422	96.0	1.44
1898	0.1	8000	Major	C	450	heb220	60	355	700	8 d25	Yes	4741248	118.3	1.34
1899	0.1	8000	Major	S	400	heb260	60	355	500	8 d14	Yes	5161219	83.1	1.47
1900	0.1	8000	Major	S	400	heb260	60	355	700	8 d25	Yes	6031232	90.1	1.38
1901	0.1	8000	Minor	C	450	heb220	60	355	500	8 d14	Yes	3429191.25	77.5	1.48
1902	0.1	8000	Minor	C	450	heb220	60	355	700	8 d25	Yes	3826162.25	125.5	1.32
1903	0.1	8000	Minor	S	400	heb260	60	355	500	8 d14	Yes	4229093	79.4	1.49
1904	0.1	8000	Minor	S	400	heb260	60	355	700	8 d25	Yes	4610011.5	117.2	1.34
1905	0.1	8000	Major	C	450	heb220	60	460	500	8 d14	Yes	4086122.5	101.3	1.42
1906	0.1	8000	Major	C	450	heb220	60	460	700	8 d25	Yes	5023408	121.2	1.33
1907	0.1	8000	Major	S	400	heb260	60	460	500	8 d14	Yes	5645323.5	92.9	1.44
1908	0.1	8000	Major	S	400	heb260	60	460	700	8 d25	Yes	6575109	97.2	1.37
1909	0.1	8000	Minor	C	450	heb220	60	460	500	8 d14	Yes	3440795.25	77.4	1.46
1910	0.1	8000	Minor	C	450	heb220	60	460	700	8 d25	Yes	3883668.5	125.4	1.31
1911	0.1	8000	Minor	S	400	heb260	60	460	500	8 d14	Yes	3695227.25	128.6	1.43
1912	0.1	8000	Minor	S	400	heb260	60	460	700	8 d25	Yes	4769725	142.6	1.32
1913	0.1	8000	Major	C	450	heb220	60	550	500	8 d14	Yes	4117019.5	136.7	1.35
1914	0.1	8000	Major	C	450	heb220	60	550	700	8 d25	Yes	5081738	142.1	1.29
1915	0.1	8000	Major	S	400	heb260	60	550	500	8 d14	Yes	5759141.5	95.8	1.39
1916	0.1	8000	Major	S	400	heb260	60	550	700	8 d25	Yes	6793682	118.3	1.32
1917	0.1	8000	Minor	C	450	heb220	60	550	500	8 d14	Yes	3440795.25	77.4	1.43
1918	0.1	8000	Minor	C	450	heb220	60	550	700	8 d25	Yes	3899264.75	127.1	1.29
1919	0.1	8000	Minor	S	400	heb260	60	550	500	8 d14	Yes	3771072.75	127.4	1.39

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1920	0.1	8000	Minor	S	400	heb260	60	550	700	8 d25	Yes	4829787.5	143.5	1.29
1921	0.1	8000	Major	C	450	heb220	90	355	500	8 d14	Yes	4800951.5	92.4	1.48
1922	0.1	8000	Major	C	450	heb220	90	355	700	8 d25	Yes	5701668	105.4	1.36
1923	0.1	8000	Major	S	400	heb260	90	355	500	8 d14	Yes	6269450.5	87.6	1.51
1924	0.1	8000	Major	S	400	heb260	90	355	700	8 d25	Yes	7192679.5	91.1	1.43
1925	0.1	8000	Minor	C	450	heb220	90	355	500	8 d14	Yes	4217530	82.9	1.53
1926	0.1	8000	Minor	C	450	heb220	90	355	700	8 d25	Yes	4689846	132.4	1.30
1927	0.1	8000	Minor	S	400	heb260	90	355	500	8 d14	Yes	5297358	81.1	1.55
1928	0.1	8000	Minor	S	400	heb260	90	355	700	8 d25	Yes	5589543	131.3	1.38
1929	0.1	8000	Major	C	450	heb220	90	460	500	8 d14	Yes	4903929.5	94.3	1.46
1930	0.1	8000	Major	C	450	heb220	90	460	700	8 d25	Yes	5911340	114.3	1.34
1931	0.1	8000	Major	S	400	heb260	90	460	500	8 d14	Yes	6737054	93.1	1.49
1932	0.1	8000	Major	S	400	heb260	90	460	700	8 d25	Yes	7711410	100.1	1.41
1933	0.1	8000	Minor	C	450	heb220	90	460	500	8 d14	Yes	4235781	82.8	1.50
1934	0.1	8000	Minor	C	450	heb220	90	460	700	8 d25	Yes	4743526.5	132.5	1.28
1935	0.1	8000	Minor	S	400	heb260	90	460	500	8 d14	Yes	5375192.5	86.4	1.52
1936	0.1	8000	Minor	S	400	heb260	90	460	700	8 d25	Yes	5714614	134.8	1.35
1937	0.1	8000	Major	C	450	heb220	90	550	500	8 d14	Yes	4903962	94.3	1.40
1938	0.1	8000	Major	C	450	heb220	90	550	700	8 d25	Yes	5951339.5	123.0	1.28
1939	0.1	8000	Major	S	400	heb260	90	550	500	8 d14	Yes	6840412.5	96.7	1.43
1940	0.1	8000	Major	S	400	heb260	90	550	700	8 d25	Yes	7907135.5	119.5	1.35
1941	0.1	8000	Minor	C	450	heb220	90	550	500	8 d14	Yes	4235781	82.8	1.47
1942	0.1	8000	Minor	C	450	heb220	90	550	700	8 d25	Yes	4764973.5	132.3	1.27
1943	0.1	8000	Minor	S	400	heb260	90	550	500	8 d14	Yes	5379479	86.4	1.48
1944	0.1	8000	Minor	S	400	heb260	90	550	700	8 d25	Yes	5748360.5	134.8	1.32
1945	0.1	10000	Major	C	450	heb220	30	355	500	8 d14	Yes	2255217.5	145.9	1.40
1946	0.1	10000	Major	C	450	heb220	30	355	700	8 d25	Yes	2846134.25	167.1	1.30
1947	0.1	10000	Major	S	400	heb260	30	355	500	8 d14	Yes	3127067.25	136.2	1.38
1948	0.1	10000	Major	S	400	heb260	30	355	700	8 d25	Yes	3760264.5	130.9	1.30
1949	0.1	10000	Minor	C	450	heb220	30	355	500	8 d14	Yes	1596804.375	158.9	1.40
1950	0.1	10000	Minor	C	450	heb220	30	355	700	8 d25	Yes	2178153.5	182.3	1.28
1951	0.1	10000	Minor	S	400	heb260	30	355	500	8 d14	Yes	2054448.75	157.1	1.39
1952	0.1	10000	Minor	S	400	heb260	30	355	700	8 d25	Yes	2675629.75	180.9	1.28
1953	0.1	10000	Major	C	450	heb220	30	460	500	8 d14	Yes	2322177	178.3	1.37
1954	0.1	10000	Major	C	450	heb220	30	460	700	8 d25	Yes	2955058.75	176.0	1.29
1955	0.1	10000	Major	S	400	heb260	30	460	500	8 d14	Yes	3375688.5	163.2	1.36
1956	0.1	10000	Major	S	400	heb260	30	460	700	8 d25	Yes	4057413.25	162.4	1.30
1957	0.1	10000	Minor	C	450	heb220	30	460	500	8 d14	Yes	1614481.25	158.6	1.39
1958	0.1	10000	Minor	C	450	heb220	30	460	700	8 d25	Yes	2212734	182.2	1.28
1959	0.1	10000	Minor	S	400	heb260	30	460	500	8 d14	Yes	2119939.5	156.2	1.37
1960	0.1	10000	Minor	S	400	heb260	30	460	700	8 d25	Yes	2760081.25	180.7	1.28
1961	0.1	10000	Major	C	450	heb220	30	550	500	8 d14	Yes	2327561.75	178.2	1.32
1962	0.1	10000	Major	C	450	heb220	30	550	700	8 d25	Yes	2962398.5	175.9	1.26
1963	0.1	10000	Major	S	400	heb260	30	550	500	8 d14	Yes	3434597.75	162.6	1.31
1964	0.1	10000	Major	S	400	heb260	30	550	700	8 d25	Yes	4124617.5	162.0	1.26
1965	0.1	10000	Minor	C	450	heb220	30	550	500	8 d14	Yes	1614481.25	158.6	1.36
1966	0.1	10000	Minor	C	450	heb220	30	550	700	8 d25	Yes	2212734	182.2	1.25
1967	0.1	10000	Minor	S	400	heb260	30	550	500	8 d14	Yes	2120377.5	156.2	1.33
1968	0.1	10000	Minor	S	400	heb260	30	550	700	8 d25	Yes	2783337.25	180.4	1.25
1969	0.1	10000	Major	C	450	heb220	60	355	500	8 d14	Yes	2821772.25	155.1	1.39
1970	0.1	10000	Major	C	450	heb220	60	355	700	8 d25	Yes	3471845	172.5	1.31
1971	0.1	10000	Major	S	400	heb260	60	355	500	8 d14	Yes	3847413.25	142.1	1.42
1972	0.1	10000	Major	S	400	heb260	60	355	700	8 d25	Yes	4536107	133.6	1.35
1973	0.1	10000	Minor	C	450	heb220	60	355	500	8 d14	Yes	2702288.75	95.0	1.47

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
1974	0.1	10000	Minor	C	450	heb220	60	355	700	8 d25	Yes	2773898.5	156.4	1.30
1975	0.1	10000	Minor	S	400	heb260	60	355	500	8 d14	Yes	2702098.75	81.5	1.47
1976	0.1	10000	Minor	S	400	heb260	60	355	700	8 d25	Yes	3390202.75	155.8	1.33
1977	0.1	10000	Major	C	450	heb220	60	460	500	8 d14	Yes	2872168.5	158.2	1.37
1978	0.1	10000	Major	C	450	heb220	60	460	700	8 d25	Yes	3565945.25	185.2	1.30
1979	0.1	10000	Major	S	400	heb260	60	460	500	8 d14	Yes	4076004.25	143.2	1.40
1980	0.1	10000	Major	S	400	heb260	60	460	700	8 d25	Yes	4803280	163.2	1.33
1981	0.1	10000	Minor	C	450	heb220	60	460	500	8 d14	Yes	2138568.25	79.8	1.45
1982	0.1	10000	Minor	C	450	heb220	60	460	700	8 d25	Yes	2793354.75	156.2	1.29
1983	0.1	10000	Minor	S	400	heb260	60	460	500	8 d14	Yes	2724865.75	164.5	1.42
1984	0.1	10000	Minor	S	400	heb260	60	460	700	8 d25	Yes	3456985.5	155.3	1.31
1985	0.1	10000	Major	C	450	heb220	60	550	500	8 d14	Yes	2872067.25	158.2	1.33
1986	0.1	10000	Major	C	450	heb220	60	550	700	8 d25	Yes	3570856	185.2	1.27
1987	0.1	10000	Major	S	400	heb260	60	550	500	8 d14	Yes	4128586.75	172.9	1.34
1988	0.1	10000	Major	S	400	heb260	60	550	700	8 d25	Yes	4858200	171.7	1.29
1989	0.1	10000	Minor	C	450	heb220	60	550	500	8 d14	Yes	2138568.25	79.8	1.43
1990	0.1	10000	Minor	C	450	heb220	60	550	700	8 d25	Yes	2793354.75	156.2	1.27
1991	0.1	10000	Minor	S	400	heb260	60	550	500	8 d14	Yes	2727815	164.4	1.38
1992	0.1	10000	Minor	S	400	heb260	60	550	700	8 d25	Yes	3459244.75	155.3	1.29
1993	0.1	10000	Major	C	450	heb220	90	355	500	8 d14	Yes	3841499	99.2	1.39
1994	0.1	10000	Major	C	450	heb220	90	355	700	8 d25	Yes	4011429.75	177.6	1.29
1995	0.1	10000	Major	S	400	heb260	90	355	500	8 d14	Yes	5023318	103.4	1.45
1996	0.1	10000	Major	S	400	heb260	90	355	700	8 d25	Yes	5210914.5	136.6	1.39
1997	0.1	10000	Minor	C	450	heb220	90	355	500	8 d14	Yes	2555309	76.5	1.52
1998	0.1	10000	Minor	C	450	heb220	90	355	700	8 d25	Yes	3769788.75	99.0	1.28
1999	0.1	10000	Minor	S	400	heb260	90	355	500	8 d14	Yes	4016544	98.0	1.53
2000	0.1	10000	Minor	S	400	heb260	90	355	700	8 d25	Yes	4547926.5	102.7	1.35
2001	0.1	10000	Major	C	450	heb220	90	460	500	8 d14	Yes	3841245.25	99.2	1.35
2002	0.1	10000	Major	C	450	heb220	90	460	700	8 d25	Yes	4094748.25	192.1	1.25
2003	0.1	10000	Major	S	400	heb260	90	460	500	8 d14	Yes	4680700.5	148.3	1.42
2004	0.1	10000	Major	S	400	heb260	90	460	700	8 d25	Yes	5438403	169.0	1.35
2005	0.1	10000	Minor	C	450	heb220	90	460	500	8 d14	Yes	2555309	76.5	1.49
2006	0.1	10000	Minor	C	450	heb220	90	460	700	8 d25	Yes	3297904.25	161.8	1.26
2007	0.1	10000	Minor	S	400	heb260	90	460	500	8 d14	Yes	3271681.5	83.9	1.50
2008	0.1	10000	Minor	S	400	heb260	90	460	700	8 d25	Yes	4561674.5	102.6	1.33
2009	0.1	10000	Major	C	450	heb220	90	550	500	8 d14	Yes	3841245.25	99.2	1.28
2010	0.1	10000	Major	C	450	heb220	90	550	700	8 d25	Yes	4099752.5	192.1	1.20
2011	0.1	10000	Major	S	400	heb260	90	550	500	8 d14	Yes	4704030.5	180.2	1.36
2012	0.1	10000	Major	S	400	heb260	90	550	700	8 d25	Yes	5496818.5	178.8	1.31
2013	0.1	10000	Minor	C	450	heb220	90	550	500	8 d14	Yes	2555309	76.5	1.46
2014	0.1	10000	Minor	C	450	heb220	90	550	700	8 d25	Yes	3297904.25	161.8	1.24
2015	0.1	10000	Minor	S	400	heb260	90	550	500	8 d14	Yes	3271681.5	83.9	1.47
2016	0.1	10000	Minor	S	400	heb260	90	550	700	8 d25	Yes	4561674.5	102.6	1.30
2017	0	3000	Major	C	450	heb220	50	355	500	8 d14	Yes	11526911	8.5	1.62
2018	0	3000	Major	C	450	heb220	50	355	700	8 d25	Yes	13891097	7.7	1.49
2019	0	3000	Major	S	400	heb260	50	355	500	8 d14	Yes	12413864	9.5	1.56
2020	0	3000	Major	S	400	heb260	50	355	700	8 d25	Yes	14740754	7.5	1.46
2021	0	3000	Minor	C	450	heb220	50	355	500	8 d14	Yes	11600889	8.8	1.62
2022	0	3000	Minor	C	450	heb220	50	355	700	8 d25	Yes	13895117	7.6	1.49
2023	0	3000	Minor	S	400	heb260	50	355	500	8 d14	Yes	12414773	9.3	1.56
2024	0	3000	Minor	S	400	heb260	50	355	700	8 d25	Yes	14733309	7.6	1.46
2025	0	3000	Major	C	450	heb220	50	460	500	8 d14	Yes	12597529	9.2	1.58
2026	0	3000	Major	C	450	heb220	50	460	700	8 d25	Yes	14911390	7.7	1.48
2027	0	3000	Major	S	400	heb260	50	460	500	8 d14	Yes	13779950	9.2	1.53

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
2028	0	3000	Major	S	400	heb260	50	460	700	8 d25	Yes	16129502	8.6	1.44
2029	0	3000	Minor	C	450	heb220	50	460	500	8 d14	Yes	12569934	9.7	1.58
2030	0	3000	Minor	C	450	heb220	50	460	700	8 d25	Yes	14916428	7.6	1.48
2031	0	3000	Minor	S	400	heb260	50	460	500	8 d14	Yes	13721822	10.7	1.53
2032	0	3000	Minor	S	400	heb260	50	460	700	8 d25	Yes	16125959	8.7	1.44
2033	0	3000	Major	C	450	heb220	50	550	500	8 d14	Yes	13213879	8.7	1.52
2034	0	3000	Major	C	450	heb220	50	550	700	8 d25	Yes	15526897	7.8	1.43
2035	0	3000	Major	S	400	heb260	50	550	500	8 d14	Yes	14621506	9.0	1.46
2036	0	3000	Major	S	400	heb260	50	550	700	8 d25	Yes	16938894	8.4	1.39
2037	0	3000	Minor	C	450	heb220	50	550	500	8 d14	Yes	13091405	9.1	1.52
2038	0	3000	Minor	C	450	heb220	50	550	700	8 d25	Yes	15500135	8.5	1.43
2039	0	3000	Minor	S	400	heb260	50	550	500	8 d14	Yes	14447715	10.7	1.46
2040	0	3000	Minor	S	400	heb260	50	550	700	8 d25	Yes	16848846	9.0	1.39
2041	0	6000	Major	C	450	heb220	50	355	500	8 d14	Yes	8429901	38.7	1.51
2042	0	6000	Major	C	450	heb220	50	355	700	8 d25	Yes	9954825	40.5	1.40
2043	0	6000	Major	S	400	heb260	50	355	500	8 d14	Yes	9387421	32.8	1.49
2044	0	6000	Major	S	400	heb260	50	355	700	8 d25	Yes	10921623	35.1	1.39
2045	0	6000	Minor	C	450	heb220	50	355	500	8 d14	Yes	7967515	46.4	1.50
2046	0	6000	Minor	C	450	heb220	50	355	700	8 d25	Yes	9083987	47.9	1.39
2047	0	6000	Minor	S	400	heb260	50	355	500	8 d14	Yes	8710069	41.0	1.49
2048	0	6000	Minor	S	400	heb260	50	355	700	8 d25	Yes	10275520	46.1	1.39
2049	0	6000	Major	C	450	heb220	50	460	500	8 d14	Yes	8947959	32.0	1.49
2050	0	6000	Major	C	450	heb220	50	460	700	8 d25	Yes	10496525	36.8	1.40
2051	0	6000	Major	S	400	heb260	50	460	500	8 d14	Yes	11078949	32.2	1.47
2052	0	6000	Major	S	400	heb260	50	460	700	8 d25	Yes	11993728	31.7	1.39
2053	0	6000	Minor	C	450	heb220	50	460	500	8 d14	Yes	7933241	43.3	1.49
2054	0	6000	Minor	C	450	heb220	50	460	700	8 d25	Yes	9559758	45.6	1.39
2055	0	6000	Minor	S	400	heb260	50	460	500	8 d14	Yes	8902933	39.1	1.47
2056	0	6000	Minor	S	400	heb260	50	460	700	8 d25	Yes	10591938	41.7	1.39
2057	0	6000	Major	C	450	heb220	50	550	500	8 d14	Yes	9290712	38.6	1.44
2058	0	6000	Major	C	450	heb220	50	550	700	8 d25	Yes	11005538	38.4	1.36
2059	0	6000	Major	S	400	heb260	50	550	500	8 d14	Yes	11041873	31.1	1.41
2060	0	6000	Major	S	400	heb260	50	550	700	8 d25	Yes	12778611	32.2	1.35
2061	0	6000	Minor	C	450	heb220	50	550	500	8 d14	Yes	8090729	44.3	1.46
2062	0	6000	Minor	C	450	heb220	50	550	700	8 d25	Yes	9777033	45.9	1.35
2063	0	6000	Minor	S	400	heb260	50	550	500	8 d14	Yes	9171470	38.5	1.42
2064	0	6000	Minor	S	400	heb260	50	550	700	8 d25	Yes	10948018	43.1	1.35
2065	0	8000	Major	C	450	heb220	50	355	500	8 d14	Yes	6065039.5	51.8	1.49
2066	0	8000	Major	C	450	heb220	50	355	700	8 d25	Yes	6951219	57.0	1.39
2067	0	8000	Major	S	400	heb260	50	355	500	8 d14	Yes	8052052	49.8	1.47
2068	0	8000	Major	S	400	heb260	50	355	700	8 d25	Yes	9118425	51.5	1.39
2069	0	8000	Minor	C	450	heb220	50	355	500	8 d14	Yes	5302910	58.0	1.50
2070	0	8000	Minor	C	450	heb220	50	355	700	8 d25	Yes	6227274	55.8	1.38
2071	0	8000	Minor	S	400	heb260	50	355	500	8 d14	Yes	5930286	52.8	1.48
2072	0	8000	Minor	S	400	heb260	50	355	700	8 d25	Yes	6919027	54.0	1.39
2073	0	8000	Major	C	450	heb220	50	460	500	8 d14	Yes	6311802	63.2	1.46
2074	0	8000	Major	C	450	heb220	50	460	700	8 d25	Yes	7334422	69.1	1.37
2075	0	8000	Major	S	400	heb260	50	460	500	8 d14	Yes	7806994	59.4	1.45
2076	0	8000	Major	S	400	heb260	50	460	700	8 d25	Yes	8944359	63.8	1.37
2077	0	8000	Minor	C	450	heb220	50	460	500	8 d14	Yes	5384806	61.6	1.48
2078	0	8000	Minor	C	450	heb220	50	460	700	8 d25	Yes	6352980.5	62.8	1.36
2079	0	8000	Minor	S	400	heb260	50	460	500	8 d14	Yes	6109855	63.2	1.46
2080	0	8000	Minor	S	400	heb260	50	460	700	8 d25	Yes	7164775.5	66.8	1.37
2081	0	8000	Major	C	450	heb220	50	550	500	8 d14	Yes	6339631	66.8	1.41

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
2082	0	8000	Major	C	450	heb220	50	550	700	8 d25	Yes	7394883.5	75.2	1.34
2083	0	8000	Major	S	400	heb260	50	550	500	8 d14	Yes	7978689	68.6	1.39
2084	0	8000	Major	S	400	heb260	50	550	700	8 d25	Yes	9206081	73.7	1.33
2085	0	8000	Minor	C	450	heb220	50	550	500	8 d14	Yes	5384836	61.6	1.45
2086	0	8000	Minor	C	450	heb220	50	550	700	8 d25	Yes	6356888	62.8	1.34
2087	0	8000	Minor	S	400	heb260	50	550	500	8 d14	Yes	6125701	63.1	1.42
2088	0	8000	Minor	S	400	heb260	50	550	700	8 d25	Yes	7197622	70.6	1.33
2089	0	10000	Major	C	450	heb220	50	355	500	8 d14	Yes	4546981	76.3	1.46
2090	0	10000	Major	C	450	heb220	50	355	700	8 d25	Yes	5202910	74.5	1.37
2091	0	10000	Major	S	400	heb260	50	355	500	8 d14	Yes	5520972	68.9	1.46
2092	0	10000	Major	S	400	heb260	50	355	700	8 d25	Yes	6232437	67.9	1.37
2093	0	10000	Minor	C	450	heb220	50	355	500	8 d14	Yes	3879622	73.6	1.48
2094	0	10000	Minor	C	450	heb220	50	355	700	8 d25	Yes	4553431	72.5	1.37
2095	0	10000	Minor	S	400	heb260	50	355	500	8 d14	Yes	4378847	77.1	1.46
2096	0	10000	Minor	S	400	heb260	50	355	700	8 d25	Yes	5084171	75.1	1.37
2097	0	10000	Major	C	450	heb220	50	460	500	8 d14	Yes	4571133	76.1	1.45
2098	0	10000	Major	C	450	heb220	50	460	700	8 d25	Yes	5232112.5	78.9	1.36
2099	0	10000	Major	S	400	heb260	50	460	500	8 d14	Yes	5619762.5	76.1	1.44
2100	0	10000	Major	S	400	heb260	50	460	700	8 d25	Yes	6343601	78.8	1.36
2101	0	10000	Minor	C	450	heb220	50	460	500	8 d14	Yes	3885140	78.7	1.47
2102	0	10000	Minor	C	450	heb220	50	460	700	8 d25	Yes	4563462.5	77.3	1.35
2103	0	10000	Minor	S	400	heb260	50	460	500	8 d14	Yes	4402572.5	76.9	1.45
2104	0	10000	Minor	S	400	heb260	50	460	700	8 d25	Yes	5114019	79.7	1.35
2105	0	10000	Major	C	450	heb220	50	550	500	8 d14	Yes	4571133	76.1	1.40
2106	0	10000	Major	C	450	heb220	50	550	700	8 d25	Yes	5232112.5	78.9	1.33
2107	0	10000	Major	S	400	heb260	50	550	500	8 d14	Yes	5619762.5	76.1	1.38
2108	0	10000	Major	S	400	heb260	50	550	700	8 d25	Yes	6343682	78.8	1.33
2109	0	10000	Minor	C	450	heb220	50	550	500	8 d14	Yes	3885140	78.7	1.44
2110	0	10000	Minor	C	450	heb220	50	550	700	8 d25	Yes	4563462.5	77.3	1.33
2111	0	10000	Minor	S	400	heb260	50	550	500	8 d14	Yes	4402572.5	76.9	1.42
2112	0	10000	Minor	S	400	heb260	50	550	700	8 d25	Yes	5114019	79.7	1.33
2113	0.1	3000	Major	C	450	heb220	50	355	500	8 d14	Yes	7489645.5	17.1	1.58
2114	0.1	3000	Major	C	450	heb220	50	355	700	8 d25	Yes	9101547	16.8	1.46
2115	0.1	3000	Major	S	400	heb260	50	355	500	8 d14	Yes	8857179	17.0	1.53
2116	0.1	3000	Major	S	400	heb260	50	355	700	8 d25	Yes	10496437	16.5	1.43
2117	0.1	3000	Minor	C	450	heb220	50	355	500	8 d14	Yes	7032053.5	19.4	1.57
2118	0.1	3000	Minor	C	450	heb220	50	355	700	8 d25	Yes	8822463	18.4	1.45
2119	0.1	3000	Minor	S	400	heb260	50	355	500	8 d14	Yes	8378721	19.7	1.52
2120	0.1	3000	Minor	S	400	heb260	50	355	700	8 d25	Yes	10189883	18.1	1.42
2121	0.1	3000	Major	C	450	heb220	50	460	500	8 d14	Yes	8240142	16.5	1.55
2122	0.1	3000	Major	C	450	heb220	50	460	700	8 d25	Yes	9856046	16.4	1.45
2123	0.1	3000	Major	S	400	heb260	50	460	500	8 d14	Yes	9941304	16.1	1.50
2124	0.1	3000	Major	S	400	heb260	50	460	700	8 d25	Yes	11566668	15.9	1.42
2125	0.1	3000	Minor	C	450	heb220	50	460	500	8 d14	Yes	7402729.5	19.3	1.53
2126	0.1	3000	Minor	C	450	heb220	50	460	700	8 d25	Yes	9217443	18.5	1.43
2127	0.1	3000	Minor	S	400	heb260	50	460	500	8 d14	Yes	9014934	19.4	1.48
2128	0.1	3000	Minor	S	400	heb260	50	460	700	8 d25	Yes	10892831	18.1	1.41
2129	0.1	3000	Major	C	450	heb220	50	550	500	8 d14	Yes	8680873	16.6	1.48
2130	0.1	3000	Major	C	450	heb220	50	550	700	8 d25	Yes	10249250	16.0	1.40
2131	0.1	3000	Major	S	400	heb260	50	550	500	8 d14	Yes	10566821	16.2	1.43
2132	0.1	3000	Major	S	400	heb260	50	550	700	8 d25	Yes	12142798	15.5	1.37
2133	0.1	3000	Minor	C	450	heb220	50	550	500	8 d14	Yes	7549510.5	19.1	1.47
2134	0.1	3000	Minor	C	450	heb220	50	550	700	8 d25	Yes	9422344	18.3	1.39
2135	0.1	3000	Minor	S	400	heb260	50	550	500	8 d14	Yes	9359370	19.9	1.42

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
2136	0.1	3000	Minor	S	400	heb260	50	550	700	8 d25	Yes	11258265	18.7	1.36
2137	0.1	6000	Major	C	450	heb220	50	355	500	8 d14	Yes	4968553	50.9	1.49
2138	0.1	6000	Major	C	450	heb220	50	355	700	8 d25	Yes	6149038	69.0	1.38
2139	0.1	6000	Major	S	400	heb260	50	355	500	8 d14	Yes	6228010.5	63.1	1.46
2140	0.1	6000	Major	S	400	heb260	50	355	700	8 d25	Yes	7490749	58.4	1.38
2141	0.1	6000	Minor	C	450	heb220	50	355	500	8 d14	Yes	3915462.25	57.0	1.50
2142	0.1	6000	Minor	C	450	heb220	50	355	700	8 d25	Yes	5233778.5	78.3	1.37
2143	0.1	6000	Minor	S	400	heb260	50	355	500	8 d14	Yes	4852135.5	56.9	1.48
2144	0.1	6000	Minor	S	400	heb260	50	355	700	8 d25	Yes	6269720	75.0	1.38
2145	0.1	6000	Major	C	450	heb220	50	460	500	8 d14	Yes	5445171	68.2	1.46
2146	0.1	6000	Major	C	450	heb220	50	460	700	8 d25	Yes	6651124	67.2	1.37
2147	0.1	6000	Major	S	400	heb260	50	460	500	8 d14	Yes	7070367.5	54.1	1.46
2148	0.1	6000	Major	S	400	heb260	50	460	700	8 d25	Yes	8337830	55.3	1.38
2149	0.1	6000	Minor	C	450	heb220	50	460	500	8 d14	Yes	4039068	60.7	1.49
2150	0.1	6000	Minor	C	450	heb220	50	460	700	8 d25	Yes	5386986	78.0	1.35
2151	0.1	6000	Minor	S	400	heb260	50	460	500	8 d14	Yes	5137545	56.7	1.46
2152	0.1	6000	Minor	S	400	heb260	50	460	700	8 d25	Yes	6586942.5	72.0	1.37
2153	0.1	6000	Major	C	450	heb220	50	550	500	8 d14	Yes	5631831.5	70.2	1.41
2154	0.1	6000	Major	C	450	heb220	50	550	700	8 d25	Yes	6858949	70.9	1.34
2155	0.1	6000	Major	S	400	heb260	50	550	500	8 d14	Yes	7443961	56.5	1.40
2156	0.1	6000	Major	S	400	heb260	50	550	700	8 d25	Yes	8773509	57.5	1.34
2157	0.1	6000	Minor	C	450	heb220	50	550	500	8 d14	Yes	4051980.25	63.2	1.45
2158	0.1	6000	Minor	C	450	heb220	50	550	700	8 d25	Yes	5444211.5	73.7	1.34
2159	0.1	6000	Minor	S	400	heb260	50	550	500	8 d14	Yes	5219086	58.2	1.42
2160	0.1	6000	Minor	S	400	heb260	50	550	700	8 d25	Yes	6705893.5	71.3	1.33
2161	0.1	8000	Major	C	450	heb220	50	355	500	8 d14	Yes	3636726	96.8	1.45
2162	0.1	8000	Major	C	450	heb220	50	355	700	8 d25	Yes	4439100.5	119.1	1.35
2163	0.1	8000	Major	S	400	heb260	50	355	500	8 d14	Yes	4787550.5	76.2	1.45
2164	0.1	8000	Major	S	400	heb260	50	355	700	8 d25	Yes	5641355	91.1	1.37
2165	0.1	8000	Minor	C	450	heb220	50	355	500	8 d14	Yes	3114902.75	73.0	1.49
2166	0.1	8000	Minor	C	450	heb220	50	355	700	8 d25	Yes	3530435.75	120.8	1.34
2167	0.1	8000	Minor	S	400	heb260	50	355	500	8 d14	Yes	3862804.75	75.4	1.48
2168	0.1	8000	Minor	S	400	heb260	50	355	700	8 d25	Yes	4299547	142.3	1.33
2169	0.1	8000	Major	C	450	heb220	50	460	500	8 d14	Yes	3792922.25	101.8	1.43
2170	0.1	8000	Major	C	450	heb220	50	460	700	8 d25	Yes	4721966	120.4	1.34
2171	0.1	8000	Major	S	400	heb260	50	460	500	8 d14	Yes	5274797.5	95.5	1.43
2172	0.1	8000	Major	S	400	heb260	50	460	700	8 d25	Yes	6197706.5	97.5	1.36
2173	0.1	8000	Minor	C	450	heb220	50	460	500	8 d14	Yes	3123227.75	78.1	1.44
2174	0.1	8000	Minor	C	450	heb220	50	460	700	8 d25	Yes	3596619	144.2	1.32
2175	0.1	8000	Minor	S	400	heb260	50	460	500	8 d14	Yes	3448948.5	123.9	1.43
2176	0.1	8000	Minor	S	400	heb260	50	460	700	8 d25	Yes	4475920	140.5	1.33
2177	0.1	8000	Major	C	450	heb220	50	550	500	8 d14	Yes	3833656.25	136.6	1.37
2178	0.1	8000	Major	C	450	heb220	50	550	700	8 d25	Yes	4794514.5	140.2	1.30
2179	0.1	8000	Major	S	400	heb260	50	550	500	8 d14	Yes	5401100.5	97.9	1.37
2180	0.1	8000	Major	S	400	heb260	50	550	700	8 d25	Yes	6434065.5	117.1	1.31
2181	0.1	8000	Minor	C	450	heb220	50	550	500	8 d14	Yes	3123227.75	78.1	1.41
2182	0.1	8000	Minor	C	450	heb220	50	550	700	8 d25	Yes	3620064.25	144.1	1.30
2183	0.1	8000	Minor	S	400	heb260	50	550	500	8 d14	Yes	3520224.75	124.7	1.39
2184	0.1	8000	Minor	S	400	heb260	50	550	700	8 d25	Yes	4529302.5	141.6	1.31
2185	0.1	10000	Major	C	450	heb220	50	355	500	8 d14	Yes	2664586.25	153.0	1.41
2186	0.1	10000	Major	C	450	heb220	50	355	700	8 d25	Yes	3286471	170.4	1.33
2187	0.1	10000	Major	S	400	heb260	50	355	500	8 d14	Yes	3622830.25	139.5	1.42
2188	0.1	10000	Major	S	400	heb260	50	355	700	8 d25	Yes	4295185	133.0	1.35
2189	0.1	10000	Minor	C	450	heb220	50	355	500	8 d14	Yes	1950465.875	76.5	1.48

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
2190	0.1	10000	Minor	C	450	heb220	50	355	700	8 d25	Yes	2590310.5	152.5	1.32
2191	0.1	10000	Minor	S	400	heb260	50	355	500	8 d14	Yes	2477087	162.4	1.43
2192	0.1	10000	Minor	S	400	heb260	50	355	700	8 d25	Yes	3177098.75	153.7	1.33
2193	0.1	10000	Major	C	450	heb220	50	460	500	8 d14	Yes	2713013	154.2	1.40
2194	0.1	10000	Major	C	450	heb220	50	460	700	8 d25	Yes	3382361.75	182.3	1.32
2195	0.1	10000	Major	S	400	heb260	50	460	500	8 d14	Yes	3849158.25	140.5	1.41
2196	0.1	10000	Major	S	400	heb260	50	460	700	8 d25	Yes	4573937	160.3	1.34
2197	0.1	10000	Minor	C	450	heb220	50	460	500	8 d14	Yes	1964557.125	166.1	1.42
2198	0.1	10000	Minor	C	450	heb220	50	460	700	8 d25	Yes	2617043	187.7	1.30
2199	0.1	10000	Minor	S	400	heb260	50	460	500	8 d14	Yes	2545296.25	161.4	1.42
2200	0.1	10000	Minor	S	400	heb260	50	460	700	8 d25	Yes	3245083.75	153.3	1.33
2201	0.1	10000	Major	C	450	heb220	50	550	500	8 d14	Yes	2713013	154.2	1.36
2202	0.1	10000	Major	C	450	heb220	50	550	700	8 d25	Yes	3389655.25	182.3	1.29
2203	0.1	10000	Major	S	400	heb260	50	550	500	8 d14	Yes	3904209.75	169.7	1.34
2204	0.1	10000	Major	S	400	heb260	50	550	700	8 d25	Yes	4633748.5	168.7	1.30
2205	0.1	10000	Minor	C	450	heb220	50	550	500	8 d14	Yes	1964557.125	166.1	1.39
2206	0.1	10000	Minor	C	450	heb220	50	550	700	8 d25	Yes	2616997.25	187.7	1.29
2207	0.1	10000	Minor	S	400	heb260	50	550	500	8 d14	Yes	2547072	161.3	1.38
2208	0.1	10000	Minor	S	400	heb260	50	550	700	8 d25	Yes	3248352.25	185.3	1.29
2209	0.2	3000	Major	C	450	heb220	30	355	500	8 d14	Yes	4317474	23.4	1.49
2210	0.2	3000	Major	C	450	heb220	30	355	700	8 d25	Yes	5555009.5	22.9	1.37
2211	0.2	3000	Major	S	400	heb260	30	355	500	8 d14	Yes	5527059.5	22.4	1.43
2212	0.2	3000	Major	S	400	heb260	30	355	700	8 d25	Yes	6832280	22.0	1.34
2213	0.2	3000	Minor	C	450	heb220	30	355	500	8 d14	Yes	3566590.25	28.2	1.46
2214	0.2	3000	Minor	C	450	heb220	30	355	700	8 d25	Yes	5050361	27.2	1.35
2215	0.2	3000	Minor	S	400	heb260	30	355	500	8 d14	Yes	4683128.5	29.0	1.42
2216	0.2	3000	Minor	S	400	heb260	30	355	700	8 d25	Yes	6233072	27.2	1.33
2217	0.2	3000	Major	C	450	heb220	30	460	500	8 d14	Yes	4867777	23.7	1.45
2218	0.2	3000	Major	C	450	heb220	30	460	700	8 d25	Yes	6095901.5	22.8	1.36
2219	0.2	3000	Major	S	400	heb260	30	460	500	8 d14	Yes	6349731.5	22.3	1.41
2220	0.2	3000	Major	S	400	heb260	30	460	700	8 d25	Yes	7645156	21.4	1.33
2221	0.2	3000	Minor	C	450	heb220	30	460	500	8 d14	Yes	3751073.25	28.2	1.44
2222	0.2	3000	Minor	C	450	heb220	30	460	700	8 d25	Yes	5275454	27.3	1.35
2223	0.2	3000	Minor	S	400	heb260	30	460	500	8 d14	Yes	5048216	29.0	1.41
2224	0.2	3000	Minor	S	400	heb260	30	460	700	8 d25	Yes	6633511	27.3	1.33
2225	0.2	3000	Major	C	450	heb220	30	550	500	8 d14	Yes	5154793	24.0	1.39
2226	0.2	3000	Major	C	450	heb220	30	550	700	8 d25	Yes	6395712	23.2	1.31
2227	0.2	3000	Major	S	400	heb260	30	550	500	8 d14	Yes	6811715.5	22.5	1.35
2228	0.2	3000	Major	S	400	heb260	30	550	700	8 d25	Yes	8116856.5	21.6	1.29
2229	0.2	3000	Minor	C	450	heb220	30	550	500	8 d14	Yes	3844763.25	29.0	1.39
2230	0.2	3000	Minor	C	450	heb220	30	550	700	8 d25	Yes	5375912	27.2	1.31
2231	0.2	3000	Minor	S	400	heb260	30	550	500	8 d14	Yes	5225522.5	29.8	1.36
2232	0.2	3000	Minor	S	400	heb260	30	550	700	8 d25	Yes	6833961	28.0	1.29
2233	0.2	3000	Major	C	450	heb220	50	355	500	8 d14	Yes	5375988.5	21.4	1.55
2234	0.2	3000	Major	C	450	heb220	50	355	700	8 d25	Yes	6625592	21.0	1.44
2235	0.2	3000	Major	S	400	heb260	50	355	500	8 d14	Yes	6814144.5	20.4	1.51
2236	0.2	3000	Major	S	400	heb260	50	355	700	8 d25	Yes	8148529.5	19.9	1.41
2237	0.2	3000	Minor	C	450	heb220	50	355	500	8 d14	Yes	4529654.5	24.6	1.53
2238	0.2	3000	Minor	C	450	heb220	50	355	700	8 d25	Yes	6029205.5	23.2	1.43
2239	0.2	3000	Minor	S	400	heb260	50	355	500	8 d14	Yes	5869210.5	25.3	1.50
2240	0.2	3000	Minor	S	400	heb260	50	355	700	8 d25	Yes	7442202	23.8	1.40
2241	0.2	3000	Major	C	450	heb220	50	460	500	8 d14	Yes	5910526.5	21.0	1.52
2242	0.2	3000	Major	C	450	heb220	50	460	700	8 d25	Yes	7185764	20.8	1.42
2243	0.2	3000	Major	S	400	heb260	50	460	500	8 d14	Yes	7641869	20.2	1.48

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
2244	0.2	3000	Major	S	400	heb260	50	460	700	8 d25	Yes	8984235	19.8	1.40
2245	0.2	3000	Minor	C	450	heb220	50	460	500	8 d14	Yes	4698666.5	24.6	1.50
2246	0.2	3000	Minor	C	450	heb220	50	460	700	8 d25	Yes	6229933	23.3	1.41
2247	0.2	3000	Minor	S	400	heb260	50	460	500	8 d14	Yes	6222523	25.2	1.48
2248	0.2	3000	Minor	S	400	heb260	50	460	700	8 d25	Yes	7833521	23.7	1.40
2249	0.2	3000	Major	C	450	heb220	50	550	500	8 d14	Yes	6179705	21.4	1.45
2250	0.2	3000	Major	C	450	heb220	50	550	700	8 d25	Yes	7453016.5	20.5	1.38
2251	0.2	3000	Major	S	400	heb260	50	550	500	8 d14	Yes	8114423	20.4	1.42
2252	0.2	3000	Major	S	400	heb260	50	550	700	8 d25	Yes	9435834	19.5	1.36
2253	0.2	3000	Minor	C	450	heb220	50	550	500	8 d14	Yes	4764098.5	24.5	1.46
2254	0.2	3000	Minor	C	450	heb220	50	550	700	8 d25	Yes	6317628.5	23.2	1.37
2255	0.2	3000	Minor	S	400	heb260	50	550	500	8 d14	Yes	6379749	25.0	1.43
2256	0.2	3000	Minor	S	400	heb260	50	550	700	8 d25	Yes	8000692	23.6	1.36
2257	0.2	3000	Major	C	450	heb220	60	355	500	8 d14	Yes	5855604	20.3	1.58
2258	0.2	3000	Major	C	450	heb220	60	355	700	8 d25	Yes	7129826.5	19.9	1.47
2259	0.2	3000	Major	S	400	heb260	60	355	500	8 d14	Yes	7406882	19.2	1.55
2260	0.2	3000	Major	S	400	heb260	60	355	700	8 d25	Yes	8754081	18.7	1.45
2261	0.2	3000	Minor	C	450	heb220	60	355	500	8 d14	Yes	4975826.5	23.1	1.56
2262	0.2	3000	Minor	C	450	heb220	60	355	700	8 d25	Yes	6477569.5	22.0	1.45
2263	0.2	3000	Minor	S	400	heb260	60	355	500	8 d14	Yes	6437276	23.6	1.53
2264	0.2	3000	Minor	S	400	heb260	60	355	700	8 d25	Yes	8020040.5	22.3	1.44
2265	0.2	3000	Major	C	450	heb220	60	460	500	8 d14	Yes	6372742.5	19.9	1.54
2266	0.2	3000	Major	C	450	heb220	60	460	700	8 d25	Yes	7662040	19.8	1.45
2267	0.2	3000	Major	S	400	heb260	60	460	500	8 d14	Yes	8288032.5	19.6	1.52
2268	0.2	3000	Major	S	400	heb260	60	460	700	8 d25	Yes	9598300	18.6	1.44
2269	0.2	3000	Minor	C	450	heb220	60	460	500	8 d14	Yes	5143683	23.1	1.52
2270	0.2	3000	Minor	C	450	heb220	60	460	700	8 d25	Yes	6668213.5	22.0	1.43
2271	0.2	3000	Minor	S	400	heb260	60	460	500	8 d14	Yes	6776715.5	23.5	1.51
2272	0.2	3000	Minor	S	400	heb260	60	460	700	8 d25	Yes	8398289	22.2	1.43
2273	0.2	3000	Major	C	450	heb220	60	550	500	8 d14	Yes	6645801.5	20.3	1.48
2274	0.2	3000	Major	C	450	heb220	60	550	700	8 d25	Yes	7906286.5	19.5	1.41
2275	0.2	3000	Major	S	400	heb260	60	550	500	8 d14	Yes	8720590	19.3	1.46
2276	0.2	3000	Major	S	400	heb260	60	550	700	8 d25	Yes	10088087	19.0	1.40
2277	0.2	3000	Minor	C	450	heb220	60	550	500	8 d14	Yes	5200257.5	23.0	1.48
2278	0.2	3000	Minor	C	450	heb220	60	550	700	8 d25	Yes	6745670.5	22.0	1.39
2279	0.2	3000	Minor	S	400	heb260	60	550	500	8 d14	Yes	6930775.5	23.4	1.46
2280	0.2	3000	Minor	S	400	heb260	60	550	700	8 d25	Yes	8556653	22.2	1.39
2281	0.2	3000	Major	C	450	heb220	90	355	500	8 d14	Yes	7215611	17.8	1.67
2282	0.2	3000	Major	C	450	heb220	90	355	700	8 d25	Yes	8463829	17.1	1.56
2283	0.2	3000	Major	S	400	heb260	90	355	500	8 d14	Yes	9126033	16.9	1.66
2284	0.2	3000	Major	S	400	heb260	90	355	700	8 d25	Yes	10502396	16.4	1.55
2285	0.2	3000	Minor	C	450	heb220	90	355	500	8 d14	Yes	6322652.5	19.7	1.65
2286	0.2	3000	Minor	C	450	heb220	90	355	700	8 d25	Yes	7712487	18.6	1.55
2287	0.2	3000	Minor	S	400	heb260	90	355	500	8 d14	Yes	8136449.5	20.1	1.64
2288	0.2	3000	Minor	S	400	heb260	90	355	700	8 d25	Yes	9720043	19.3	1.55
2289	0.2	3000	Major	C	450	heb220	90	460	500	8 d14	Yes	7722494	17.6	1.64
2290	0.2	3000	Major	C	450	heb220	90	460	700	8 d25	Yes	8962462	17.0	1.54
2291	0.2	3000	Major	S	400	heb260	90	460	500	8 d14	Yes	9996084	16.6	1.63
2292	0.2	3000	Major	S	400	heb260	90	460	700	8 d25	Yes	11369795	16.3	1.53
2293	0.2	3000	Minor	C	450	heb220	90	460	500	8 d14	Yes	6471672	19.6	1.61
2294	0.2	3000	Minor	C	450	heb220	90	460	700	8 d25	Yes	7883159	18.7	1.52
2295	0.2	3000	Minor	S	400	heb260	90	460	500	8 d14	Yes	8457230	20.0	1.61
2296	0.2	3000	Minor	S	400	heb260	90	460	700	8 d25	Yes	10104308	19.1	1.53
2297	0.2	3000	Major	C	450	heb220	90	550	500	8 d14	Yes	7985555	18.0	1.58

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
2298	0.2	3000	Major	C	450	heb220	90	550	700	8 d25	Yes	9120282	16.9	1.50
2299	0.2	3000	Major	S	400	heb260	90	550	500	8 d14	Yes	10505613	16.9	1.57
2300	0.2	3000	Major	S	400	heb260	90	550	700	8 d25	Yes	11804660	16.1	1.49
2301	0.2	3000	Minor	C	450	heb220	90	550	500	8 d14	Yes	6520555.5	19.5	1.56
2302	0.2	3000	Minor	C	450	heb220	90	550	700	8 d25	Yes	7938035.5	18.6	1.48
2303	0.2	3000	Minor	S	400	heb260	90	550	500	8 d14	Yes	8603735	19.8	1.56
2304	0.2	3000	Minor	S	400	heb260	90	550	700	8 d25	Yes	10264917	19.0	1.48
2305	0.2	6000	Major	C	450	heb220	30	355	500	8 d14	Yes	3003679.25	79.5	1.43
2306	0.2	6000	Major	C	450	heb220	30	355	700	8 d25	Yes	3943470	86.9	1.32
2307	0.2	6000	Major	S	400	heb260	30	355	500	8 d14	Yes	3992513	74.0	1.40
2308	0.2	6000	Major	S	400	heb260	30	355	700	8 d25	Yes	5000892.5	75.1	1.32
2309	0.2	6000	Minor	C	450	heb220	30	355	500	8 d14	Yes	2141478.75	101.0	1.43
2310	0.2	6000	Minor	C	450	heb220	30	355	700	8 d25	Yes	3255856.75	103.8	1.31
2311	0.2	6000	Minor	S	400	heb260	30	355	500	8 d14	Yes	2821415.25	97.0	1.40
2312	0.2	6000	Minor	S	400	heb260	30	355	700	8 d25	Yes	4022132.5	100.3	1.30
2313	0.2	6000	Major	C	450	heb220	30	460	500	8 d14	Yes	3342304.25	86.9	1.41
2314	0.2	6000	Major	C	450	heb220	30	460	700	8 d25	Yes	4309990	90.1	1.32
2315	0.2	6000	Major	S	400	heb260	30	460	500	8 d14	Yes	4592128.5	75.6	1.39
2316	0.2	6000	Major	S	400	heb260	30	460	700	8 d25	Yes	5622809.5	76.9	1.32
2317	0.2	6000	Minor	C	450	heb220	30	460	500	8 d14	Yes	2231863.5	99.3	1.41
2318	0.2	6000	Minor	C	450	heb220	30	460	700	8 d25	Yes	3363770	103.9	1.30
2319	0.2	6000	Minor	S	400	heb260	30	460	500	8 d14	Yes	3001961.75	96.4	1.38
2320	0.2	6000	Minor	S	400	heb260	30	460	700	8 d25	Yes	4226087.5	105.6	1.29
2321	0.2	6000	Major	C	450	heb220	30	550	500	8 d14	Yes	3492268.5	93.1	1.35
2322	0.2	6000	Major	C	450	heb220	30	550	700	8 d25	Yes	4477581	92.3	1.28
2323	0.2	6000	Major	S	400	heb260	30	550	500	8 d14	Yes	4883819	80.9	1.33
2324	0.2	6000	Major	S	400	heb260	30	550	700	8 d25	Yes	5932979.5	76.4	1.28
2325	0.2	6000	Minor	C	450	heb220	30	550	500	8 d14	Yes	2264780.5	109.8	1.37
2326	0.2	6000	Minor	C	450	heb220	30	550	700	8 d25	Yes	3407974.75	106.1	1.27
2327	0.2	6000	Minor	S	400	heb260	30	550	500	8 d14	Yes	3079484.5	99.4	1.34
2328	0.2	6000	Minor	S	400	heb260	30	550	700	8 d25	Yes	4317845	107.6	1.26
2329	0.2	6000	Major	C	450	heb220	50	355	500	8 d14	Yes	3667501.25	78.9	1.47
2330	0.2	6000	Major	C	450	heb220	50	355	700	8 d25	Yes	4672347.5	87.0	1.37
2331	0.2	6000	Major	S	400	heb260	50	355	500	8 d14	Yes	4845484.5	78.2	1.46
2332	0.2	6000	Major	S	400	heb260	50	355	700	8 d25	Yes	5898752	79.6	1.37
2333	0.2	6000	Minor	C	450	heb220	50	355	500	8 d14	Yes	2688081	88.6	1.48
2334	0.2	6000	Minor	C	450	heb220	50	355	700	8 d25	Yes	3880583.75	99.4	1.35
2335	0.2	6000	Minor	S	400	heb260	50	355	500	8 d14	Yes	3500797.25	90.4	1.47
2336	0.2	6000	Minor	S	400	heb260	50	355	700	8 d25	Yes	4800614	102.1	1.36
2337	0.2	6000	Major	C	450	heb220	50	460	500	8 d14	Yes	4004501.25	88.6	1.44
2338	0.2	6000	Major	C	450	heb220	50	460	700	8 d25	Yes	5018430	86.3	1.36
2339	0.2	6000	Major	S	400	heb260	50	460	500	8 d14	Yes	5443898.5	76.5	1.44
2340	0.2	6000	Major	S	400	heb260	50	460	700	8 d25	Yes	6505650	78.0	1.37
2341	0.2	6000	Minor	C	450	heb220	50	460	500	8 d14	Yes	2762693.25	104.3	1.45
2342	0.2	6000	Minor	C	450	heb220	50	460	700	8 d25	Yes	3987042.75	100.0	1.34
2343	0.2	6000	Minor	S	400	heb260	50	460	500	8 d14	Yes	3677377.75	88.3	1.45
2344	0.2	6000	Minor	S	400	heb260	50	460	700	8 d25	Yes	4995196	102.7	1.34
2345	0.2	6000	Major	C	450	heb220	50	550	500	8 d14	Yes	4132275.25	94.5	1.40
2346	0.2	6000	Major	C	450	heb220	50	550	700	8 d25	Yes	5184876.5	90.7	1.33
2347	0.2	6000	Major	S	400	heb260	50	550	500	8 d14	Yes	5728551.5	84.2	1.38
2348	0.2	6000	Major	S	400	heb260	50	550	700	8 d25	Yes	6808858.5	77.7	1.33
2349	0.2	6000	Minor	C	450	heb220	50	550	500	8 d14	Yes	2794610.5	101.9	1.43
2350	0.2	6000	Minor	C	450	heb220	50	550	700	8 d25	Yes	4021224	100.5	1.32
2351	0.2	6000	Minor	S	400	heb260	50	550	500	8 d14	Yes	3753735.75	102.6	1.41

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
2352	0.2	6000	Minor	S	400	heb260	50	550	700	8 d25	Yes	5080555.5	102.6	1.32
2353	0.2	6000	Major	C	450	heb220	60	355	500	8 d14	Yes	3967841.25	78.0	1.47
2354	0.2	6000	Major	C	450	heb220	60	355	700	8 d25	Yes	4976633.5	81.7	1.37
2355	0.2	6000	Major	S	400	heb260	60	355	500	8 d14	Yes	5251063	77.3	1.47
2356	0.2	6000	Major	S	400	heb260	60	355	700	8 d25	Yes	6326134	79.9	1.39
2357	0.2	6000	Minor	C	450	heb220	60	355	500	8 d14	Yes	2942348	87.5	1.47
2358	0.2	6000	Minor	C	450	heb220	60	355	700	8 d25	Yes	4173628.75	91.8	1.34
2359	0.2	6000	Minor	S	400	heb260	60	355	500	8 d14	Yes	3828779.75	92.0	1.47
2360	0.2	6000	Minor	S	400	heb260	60	355	700	8 d25	Yes	5169671.5	96.2	1.37
2361	0.2	6000	Major	C	450	heb220	60	460	500	8 d14	Yes	4307783.5	86.8	1.44
2362	0.2	6000	Major	C	450	heb220	60	460	700	8 d25	Yes	5335107.5	85.7	1.36
2363	0.2	6000	Major	S	400	heb260	60	460	500	8 d14	Yes	5846322.5	75.7	1.46
2364	0.2	6000	Major	S	400	heb260	60	460	700	8 d25	Yes	6926782	77.5	1.38
2365	0.2	6000	Minor	C	450	heb220	60	460	500	8 d14	Yes	3021792	99.7	1.44
2366	0.2	6000	Minor	C	450	heb220	60	460	700	8 d25	Yes	4264363.5	92.7	1.33
2367	0.2	6000	Minor	S	400	heb260	60	460	500	8 d14	Yes	3999352.5	93.8	1.45
2368	0.2	6000	Minor	S	400	heb260	60	460	700	8 d25	Yes	5358172.5	97.0	1.35
2369	0.2	6000	Major	C	450	heb220	60	550	500	8 d14	Yes	4423766	88.7	1.39
2370	0.2	6000	Major	C	450	heb220	60	550	700	8 d25	Yes	5480856	87.2	1.33
2371	0.2	6000	Major	S	400	heb260	60	550	500	8 d14	Yes	6132315	83.4	1.40
2372	0.2	6000	Major	S	400	heb260	60	550	700	8 d25	Yes	7225784	82.5	1.34
2373	0.2	6000	Minor	C	450	heb220	60	550	500	8 d14	Yes	3097454.75	103.3	1.41
2374	0.2	6000	Minor	C	450	heb220	60	550	700	8 d25	Yes	4293886	92.5	1.31
2375	0.2	6000	Minor	S	400	heb260	60	550	500	8 d14	Yes	4074692.25	93.2	1.42
2376	0.2	6000	Minor	S	400	heb260	60	550	700	8 d25	Yes	5441243.5	96.8	1.32
2377	0.2	6000	Major	C	450	heb220	90	355	500	8 d14	Yes	4901475.5	78.2	1.51
2378	0.2	6000	Major	C	450	heb220	90	355	700	8 d25	Yes	5923775.5	75.8	1.42
2379	0.2	6000	Major	S	400	heb260	90	355	500	8 d14	Yes	6396548	74.7	1.54
2380	0.2	6000	Major	S	400	heb260	90	355	700	8 d25	Yes	7534394.5	74.7	1.45
2381	0.2	6000	Minor	C	450	heb220	90	355	500	8 d14	Yes	3728754.75	84.8	1.52
2382	0.2	6000	Minor	C	450	heb220	90	355	700	8 d25	Yes	4976186	81.1	1.39
2383	0.2	6000	Minor	S	400	heb260	90	355	500	8 d14	Yes	4820706.5	89.7	1.53
2384	0.2	6000	Minor	S	400	heb260	90	355	700	8 d25	Yes	6231316.5	88.8	1.43
2385	0.2	6000	Major	C	450	heb220	90	460	500	8 d14	Yes	5187317	80.9	1.49
2386	0.2	6000	Major	C	450	heb220	90	460	700	8 d25	Yes	6234780	77.4	1.40
2387	0.2	6000	Major	S	400	heb260	90	460	500	8 d14	Yes	7022051	75.4	1.52
2388	0.2	6000	Major	S	400	heb260	90	460	700	8 d25	Yes	8168108	74.7	1.44
2389	0.2	6000	Minor	C	450	heb220	90	460	500	8 d14	Yes	3789799	84.3	1.49
2390	0.2	6000	Minor	C	450	heb220	90	460	700	8 d25	Yes	5049228.5	82.4	1.37
2391	0.2	6000	Minor	S	400	heb260	90	460	500	8 d14	Yes	4977327.5	90.5	1.50
2392	0.2	6000	Minor	S	400	heb260	90	460	700	8 d25	Yes	6410085.5	88.7	1.41
2393	0.2	6000	Major	C	450	heb220	90	550	500	8 d14	Yes	5251383.5	81.9	1.44
2394	0.2	6000	Major	C	450	heb220	90	550	700	8 d25	Yes	6300346.5	77.2	1.37
2395	0.2	6000	Major	S	400	heb260	90	550	500	8 d14	Yes	7307743.5	77.6	1.46
2396	0.2	6000	Major	S	400	heb260	90	550	700	8 d25	Yes	8478958	75.7	1.40
2397	0.2	6000	Minor	C	450	heb220	90	550	500	8 d14	Yes	3809430.25	84.0	1.46
2398	0.2	6000	Minor	C	450	heb220	90	550	700	8 d25	Yes	5073946.5	83.6	1.34
2399	0.2	6000	Minor	S	400	heb260	90	550	500	8 d14	Yes	5040706	93.1	1.46
2400	0.2	6000	Minor	S	400	heb260	90	550	700	8 d25	Yes	6485258.5	89.6	1.38
2401	0.2	8000	Major	C	450	heb220	30	355	500	8 d14	Yes	2318624	123.0	1.40
2402	0.2	8000	Major	C	450	heb220	30	355	700	8 d25	Yes	2999452	122.2	1.31
2403	0.2	8000	Major	S	400	heb260	30	355	500	8 d14	Yes	3207767.5	107.1	1.39
2404	0.2	8000	Major	S	400	heb260	30	355	700	8 d25	Yes	3953133	116.9	1.30
2405	0.2	8000	Minor	C	450	heb220	30	355	500	8 d14	Yes	1567358.75	143.2	1.41

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
2406	0.2	8000	Minor	C	450	heb220	30	355	700	8 d25	Yes	2326608.25	135.2	1.29
2407	0.2	8000	Minor	S	400	heb260	30	355	500	8 d14	Yes	2058890	131.5	1.39
2408	0.2	8000	Minor	S	400	heb260	30	355	700	8 d25	Yes	2920541.25	137.3	1.29
2409	0.2	8000	Major	C	450	heb220	30	460	500	8 d14	Yes	2475201	128.8	1.39
2410	0.2	8000	Major	C	450	heb220	30	460	700	8 d25	Yes	3149232	121.6	1.31
2411	0.2	8000	Major	S	400	heb260	30	460	500	8 d14	Yes	3608662	119.8	1.38
2412	0.2	8000	Major	S	400	heb260	30	460	700	8 d25	Yes	4369514	115.5	1.31
2413	0.2	8000	Minor	C	450	heb220	30	460	500	8 d14	Yes	1604363	142.5	1.40
2414	0.2	8000	Minor	C	450	heb220	30	460	700	8 d25	Yes	2371656.5	135.1	1.29
2415	0.2	8000	Minor	S	400	heb260	30	460	500	8 d14	Yes	2151490.75	148.6	1.38
2416	0.2	8000	Minor	S	400	heb260	30	460	700	8 d25	Yes	3032306.5	137.1	1.28
2417	0.2	8000	Major	C	450	heb220	30	550	500	8 d14	Yes	2489449.5	128.6	1.34
2418	0.2	8000	Major	C	450	heb220	30	550	700	8 d25	Yes	3163606.5	121.5	1.28
2419	0.2	8000	Major	S	400	heb260	30	550	500	8 d14	Yes	3731923.25	118.9	1.32
2420	0.2	8000	Major	S	400	heb260	30	550	700	8 d25	Yes	4487666	114.9	1.27
2421	0.2	8000	Minor	C	450	heb220	30	550	500	8 d14	Yes	1610359.125	142.3	1.36
2422	0.2	8000	Minor	C	450	heb220	30	550	700	8 d25	Yes	2376560	135.0	1.26
2423	0.2	8000	Minor	S	400	heb260	30	550	500	8 d14	Yes	2187083.5	148.1	1.33
2424	0.2	8000	Minor	S	400	heb260	30	550	700	8 d25	Yes	3069155.75	136.9	1.26
2425	0.2	8000	Major	C	450	heb220	50	355	500	8 d14	Yes	2770551.25	126.9	1.43
2426	0.2	8000	Major	C	450	heb220	50	355	700	8 d25	Yes	3454506.75	153.5	1.33
2427	0.2	8000	Major	S	400	heb260	50	355	500	8 d14	Yes	3755413.5	106.0	1.44
2428	0.2	8000	Major	S	400	heb260	50	355	700	8 d25	Yes	4473449.5	131.6	1.35
2429	0.2	8000	Minor	C	450	heb220	50	355	500	8 d14	Yes	1913021.5	147.9	1.44
2430	0.2	8000	Minor	C	450	heb220	50	355	700	8 d25	Yes	2766320.25	139.7	1.33
2431	0.2	8000	Minor	S	400	heb260	50	355	500	8 d14	Yes	2510107.25	133.8	1.45
2432	0.2	8000	Minor	S	400	heb260	50	355	700	8 d25	Yes	3440218.25	141.5	1.34
2433	0.2	8000	Major	C	450	heb220	50	460	500	8 d14	Yes	2913276.75	133.4	1.41
2434	0.2	8000	Major	C	450	heb220	50	460	700	8 d25	Yes	3688354.25	160.8	1.32
2435	0.2	8000	Major	S	400	heb260	50	460	500	8 d14	Yes	4154986.5	124.6	1.41
2436	0.2	8000	Major	S	400	heb260	50	460	700	8 d25	Yes	4900608.5	133.3	1.34
2437	0.2	8000	Minor	C	450	heb220	50	460	500	8 d14	Yes	1948628.375	147.9	1.42
2438	0.2	8000	Minor	C	450	heb220	50	460	700	8 d25	Yes	2808691	139.5	1.32
2439	0.2	8000	Minor	S	400	heb260	50	460	500	8 d14	Yes	2596474.5	148.7	1.43
2440	0.2	8000	Minor	S	400	heb260	50	460	700	8 d25	Yes	3547283.5	141.3	1.33
2441	0.2	8000	Major	C	450	heb220	50	550	500	8 d14	Yes	2925912.75	133.2	1.37
2442	0.2	8000	Major	C	450	heb220	50	550	700	8 d25	Yes	3780625.25	160.6	1.29
2443	0.2	8000	Major	S	400	heb260	50	550	500	8 d14	Yes	4283821	125.1	1.36
2444	0.2	8000	Major	S	400	heb260	50	550	700	8 d25	Yes	5088844.5	142.9	1.30
2445	0.2	8000	Minor	C	450	heb220	50	550	500	8 d14	Yes	1959343.125	154.4	1.40
2446	0.2	8000	Minor	C	450	heb220	50	550	700	8 d25	Yes	2813847.25	139.4	1.30
2447	0.2	8000	Minor	S	400	heb260	50	550	500	8 d14	Yes	2629063.75	147.7	1.39
2448	0.2	8000	Minor	S	400	heb260	50	550	700	8 d25	Yes	3582051	141.1	1.31
2449	0.2	8000	Major	C	450	heb220	60	355	500	8 d14	Yes	2953729.75	128.3	1.41
2450	0.2	8000	Major	C	450	heb220	60	355	700	8 d25	Yes	3715772.5	129.1	1.33
2451	0.2	8000	Major	S	400	heb260	60	355	500	8 d14	Yes	4011959.5	106.6	1.45
2452	0.2	8000	Major	S	400	heb260	60	355	700	8 d25	Yes	4744590	131.0	1.36
2453	0.2	8000	Minor	C	450	heb220	60	355	500	8 d14	Yes	2056940.75	133.1	1.44
2454	0.2	8000	Minor	C	450	heb220	60	355	700	8 d25	Yes	2969498.75	141.5	1.31
2455	0.2	8000	Minor	S	400	heb260	60	355	500	8 d14	Yes	2708282.75	133.9	1.46
2456	0.2	8000	Minor	S	400	heb260	60	355	700	8 d25	Yes	3680873	143.4	1.33
2457	0.2	8000	Major	C	450	heb220	60	460	500	8 d14	Yes	3103996	135.9	1.39
2458	0.2	8000	Major	C	450	heb220	60	460	700	8 d25	Yes	3858383.25	128.6	1.32
2459	0.2	8000	Major	S	400	heb260	60	460	500	8 d14	Yes	4415036	126.2	1.42

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
2460	0.2	8000	Major	S	400	heb260	60	460	700	8 d25	Yes	5161696	141.0	1.34
2461	0.2	8000	Minor	C	450	heb220	60	460	500	8 d14	Yes	2093738.625	159.8	1.39
2462	0.2	8000	Minor	C	450	heb220	60	460	700	8 d25	Yes	3010057	141.4	1.30
2463	0.2	8000	Minor	S	400	heb260	60	460	500	8 d14	Yes	2793589.75	149.5	1.42
2464	0.2	8000	Minor	S	400	heb260	60	460	700	8 d25	Yes	3786976.5	143.3	1.32
2465	0.2	8000	Major	C	450	heb220	60	550	500	8 d14	Yes	3118223.75	138.0	1.35
2466	0.2	8000	Major	C	450	heb220	60	550	700	8 d25	Yes	3871747.25	128.5	1.29
2467	0.2	8000	Major	S	400	heb260	60	550	500	8 d14	Yes	4542808	127.5	1.36
2468	0.2	8000	Major	S	400	heb260	60	550	700	8 d25	Yes	5350823	142.7	1.31
2469	0.2	8000	Minor	C	450	heb220	60	550	500	8 d14	Yes	2107780.75	159.4	1.36
2470	0.2	8000	Minor	C	450	heb220	60	550	700	8 d25	Yes	3015561.75	141.3	1.28
2471	0.2	8000	Minor	S	400	heb260	60	550	500	8 d14	Yes	2829371.25	149.0	1.38
2472	0.2	8000	Minor	S	400	heb260	60	550	700	8 d25	Yes	3821782.5	143.0	1.29
2473	0.2	8000	Major	C	450	heb220	90	355	500	8 d14	Yes	3514054	130.2	1.43
2474	0.2	8000	Major	C	450	heb220	90	355	700	8 d25	Yes	4375098.5	133.9	1.33
2475	0.2	8000	Major	S	400	heb260	90	355	500	8 d14	Yes	4771755.5	121.6	1.47
2476	0.2	8000	Major	S	400	heb260	90	355	700	8 d25	Yes	5542574	141.8	1.38
2477	0.2	8000	Minor	C	450	heb220	90	355	500	8 d14	Yes	2539100.5	144.1	1.45
2478	0.2	8000	Minor	C	450	heb220	90	355	700	8 d25	Yes	3535144.5	147.0	1.29
2479	0.2	8000	Minor	S	400	heb260	90	355	500	8 d14	Yes	3383096	148.8	1.50
2480	0.2	8000	Minor	S	400	heb260	90	355	700	8 d25	Yes	4374983	148.3	1.36
2481	0.2	8000	Major	C	450	heb220	90	460	500	8 d14	Yes	3664051	144.4	1.38
2482	0.2	8000	Major	C	450	heb220	90	460	700	8 d25	Yes	4508965.5	133.5	1.32
2483	0.2	8000	Major	S	400	heb260	90	460	500	8 d14	Yes	5175173	130.0	1.44
2484	0.2	8000	Major	S	400	heb260	90	460	700	8 d25	Yes	6051429	126.9	1.38
2485	0.2	8000	Minor	C	450	heb220	90	460	500	8 d14	Yes	2575115.75	139.9	1.38
2486	0.2	8000	Minor	C	450	heb220	90	460	700	8 d25	Yes	3572285.5	146.9	1.27
2487	0.2	8000	Minor	S	400	heb260	90	460	500	8 d14	Yes	3360310.5	155.9	1.45
2488	0.2	8000	Minor	S	400	heb260	90	460	700	8 d25	Yes	4475035	148.3	1.34
2489	0.2	8000	Major	C	450	heb220	90	550	500	8 d14	Yes	3678154.75	144.2	1.30
2490	0.2	8000	Major	C	450	heb220	90	550	700	8 d25	Yes	4520296	133.4	1.26
2491	0.2	8000	Major	S	400	heb260	90	550	500	8 d14	Yes	5290563.5	133.2	1.39
2492	0.2	8000	Major	S	400	heb260	90	550	700	8 d25	Yes	6159062	126.5	1.35
2493	0.2	8000	Minor	C	450	heb220	90	550	500	8 d14	Yes	2554744	164.9	1.36
2494	0.2	8000	Minor	C	450	heb220	90	550	700	8 d25	Yes	3578764.5	146.8	1.25
2495	0.2	8000	Minor	S	400	heb260	90	550	500	8 d14	Yes	3395290.25	154.7	1.40
2496	0.2	8000	Minor	S	400	heb260	90	550	700	8 d25	Yes	4509747.5	148.1	1.31
2497	0.2	10000	Major	C	450	heb220	30	355	500	8 d14	Yes	1765909.5	156.9	1.39
2498	0.2	10000	Major	C	450	heb220	30	355	700	8 d25	Yes	2241706.25	149.0	1.30
2499	0.2	10000	Major	S	400	heb260	30	355	500	8 d14	Yes	2574836	145.7	1.38
2500	0.2	10000	Major	S	400	heb260	30	355	700	8 d25	Yes	3082161.25	143.4	1.30
2501	0.2	10000	Minor	C	450	heb220	30	355	500	8 d14	Yes	1172006.75	172.5	1.40
2502	0.2	10000	Minor	C	450	heb220	30	355	700	8 d25	Yes	1684996	162.4	1.28
2503	0.2	10000	Minor	S	400	heb260	30	355	500	8 d14	Yes	1578085.625	155.6	1.39
2504	0.2	10000	Minor	S	400	heb260	30	355	700	8 d25	Yes	2141727.5	164.8	1.28
2505	0.2	10000	Major	C	450	heb220	30	460	500	8 d14	Yes	1787985	156.6	1.38
2506	0.2	10000	Major	C	450	heb220	30	460	700	8 d25	Yes	2264172.75	148.8	1.30
2507	0.2	10000	Major	S	400	heb260	30	460	500	8 d14	Yes	2707858	147.7	1.37
2508	0.2	10000	Major	S	400	heb260	30	460	700	8 d25	Yes	3217441.75	142.7	1.30
2509	0.2	10000	Minor	C	450	heb220	30	460	500	8 d14	Yes	1181457.125	172.1	1.39
2510	0.2	10000	Minor	C	450	heb220	30	460	700	8 d25	Yes	1693534.875	162.2	1.28
2511	0.2	10000	Minor	S	400	heb260	30	460	500	8 d14	Yes	1620387.625	171.4	1.37
2512	0.2	10000	Minor	S	400	heb260	30	460	700	8 d25	Yes	2190339.5	164.4	1.28
2513	0.2	10000	Major	C	450	heb220	30	550	500	8 d14	Yes	1787985	156.6	1.33

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
2514	0.2	10000	Major	C	450	heb220	30	550	700	8 d25	Yes	2264172.75	148.8	1.27
2515	0.2	10000	Major	S	400	heb260	30	550	500	8 d14	Yes	2711820.25	147.7	1.31
2516	0.2	10000	Major	S	400	heb260	30	550	700	8 d25	Yes	3221129.75	142.7	1.26
2517	0.2	10000	Minor	C	450	heb220	30	550	500	8 d14	Yes	1181457.125	172.1	1.36
2518	0.2	10000	Minor	C	450	heb220	30	550	700	8 d25	Yes	1693534.875	162.2	1.26
2519	0.2	10000	Minor	S	400	heb260	30	550	500	8 d14	Yes	1620387.625	171.4	1.33
2520	0.2	10000	Minor	S	400	heb260	30	550	700	8 d25	Yes	2190339.5	164.4	1.25
2521	0.2	10000	Major	C	450	heb220	50	355	500	8 d14	Yes	2065527.875	158.1	1.41
2522	0.2	10000	Major	C	450	heb220	50	355	700	8 d25	Yes	2578708.75	153.9	1.33
2523	0.2	10000	Major	S	400	heb260	50	355	500	8 d14	Yes	2954975.5	150.0	1.42
2524	0.2	10000	Major	S	400	heb260	50	355	700	8 d25	Yes	3483654.75	148.7	1.35
2525	0.2	10000	Minor	C	450	heb220	50	355	500	8 d14	Yes	1421353.25	160.4	1.43
2526	0.2	10000	Minor	C	450	heb220	50	355	700	8 d25	Yes	1977757.5	167.6	1.32
2527	0.2	10000	Minor	S	400	heb260	50	355	500	8 d14	Yes	1889154.875	158.6	1.44
2528	0.2	10000	Minor	S	400	heb260	50	355	700	8 d25	Yes	2487006	170.1	1.33
2529	0.2	10000	Major	C	450	heb220	50	460	500	8 d14	Yes	2085788.75	163.9	1.39
2530	0.2	10000	Major	C	450	heb220	50	460	700	8 d25	Yes	2598477	153.8	1.33
2531	0.2	10000	Major	S	400	heb260	50	460	500	8 d14	Yes	3084990	154.2	1.40
2532	0.2	10000	Major	S	400	heb260	50	460	700	8 d25	Yes	3611911.5	148.2	1.34
2533	0.2	10000	Minor	C	450	heb220	50	460	500	8 d14	Yes	1428287.25	179.3	1.41
2534	0.2	10000	Minor	C	450	heb220	50	460	700	8 d25	Yes	1986146	167.5	1.31
2535	0.2	10000	Minor	S	400	heb260	50	460	500	8 d14	Yes	1922569.5	157.8	1.42
2536	0.2	10000	Minor	S	400	heb260	50	460	700	8 d25	Yes	2532190	169.8	1.33
2537	0.2	10000	Major	C	450	heb220	50	550	500	8 d14	Yes	2085788.75	163.9	1.35
2538	0.2	10000	Major	C	450	heb220	50	550	700	8 d25	Yes	2598477	153.8	1.30
2539	0.2	10000	Major	S	400	heb260	50	550	500	8 d14	Yes	3088573.25	154.1	1.35
2540	0.2	10000	Major	S	400	heb260	50	550	700	8 d25	Yes	3615245.25	148.1	1.30
2541	0.2	10000	Minor	C	450	heb220	50	550	500	8 d14	Yes	1428287.25	179.3	1.38
2542	0.2	10000	Minor	C	450	heb220	50	550	700	8 d25	Yes	1986146	167.5	1.29
2543	0.2	10000	Minor	S	400	heb260	50	550	500	8 d14	Yes	1922569.5	157.8	1.38
2544	0.2	10000	Minor	S	400	heb260	50	550	700	8 d25	Yes	2532190	169.8	1.30
2545	0.2	10000	Major	C	450	heb220	60	355	500	8 d14	Yes	2192221.75	166.8	1.38
2546	0.2	10000	Major	C	450	heb220	60	355	700	8 d25	Yes	2723556.75	155.9	1.31
2547	0.2	10000	Major	S	400	heb260	60	355	500	8 d14	Yes	3125318.25	157.3	1.42
2548	0.2	10000	Major	S	400	heb260	60	355	700	8 d25	Yes	3676203	150.7	1.35
2549	0.2	10000	Minor	C	450	heb220	60	355	500	8 d14	Yes	1535192.75	162.0	1.42
2550	0.2	10000	Minor	C	450	heb220	60	355	700	8 d25	Yes	2145162	261.2	1.27
2551	0.2	10000	Minor	S	400	heb260	60	355	500	8 d14	Yes	2021198.125	161.4	1.44
2552	0.2	10000	Minor	S	400	heb260	60	355	700	8 d25	Yes	2645524.75	172.2	1.32
2553	0.2	10000	Major	C	450	heb220	60	460	500	8 d14	Yes	2212455	166.5	1.37
2554	0.2	10000	Major	C	450	heb220	60	460	700	8 d25	Yes	2742385.25	156.0	1.31
2555	0.2	10000	Major	S	400	heb260	60	460	500	8 d14	Yes	3251318.25	156.6	1.40
2556	0.2	10000	Major	S	400	heb260	60	460	700	8 d25	Yes	3800582.75	150.2	1.34
2557	0.2	10000	Minor	C	450	heb220	60	460	500	8 d14	Yes	1538120.625	161.8	1.39
2558	0.2	10000	Minor	C	450	heb220	60	460	700	8 d25	Yes	2162764.5	233.6	1.26
2559	0.2	10000	Minor	S	400	heb260	60	460	500	8 d14	Yes	2059198.375	160.6	1.42
2560	0.2	10000	Minor	S	400	heb260	60	460	700	8 d25	Yes	2690756.5	171.8	1.31
2561	0.2	10000	Major	C	450	heb220	60	550	500	8 d14	Yes	2212455	166.5	1.33
2562	0.2	10000	Major	C	450	heb220	60	550	700	8 d25	Yes	2742385.25	156.0	1.28
2563	0.2	10000	Major	S	400	heb260	60	550	500	8 d14	Yes	3254459.5	156.6	1.35
2564	0.2	10000	Major	S	400	heb260	60	550	700	8 d25	Yes	3803516.5	150.2	1.30
2565	0.2	10000	Minor	C	450	heb220	60	550	500	8 d14	Yes	1538120.625	161.8	1.36
2566	0.2	10000	Minor	C	450	heb220	60	550	700	8 d25	Yes	2167253	265.9	1.24
2567	0.2	10000	Minor	S	400	heb260	60	550	500	8 d14	Yes	2059198.375	160.6	1.38

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
2568	0.2	10000	Minor	S	400	heb260	60	550	700	8 d25	Yes	2690756.5	171.8	1.28
2569	0.2	10000	Major	C	450	heb220	90	355	500	8 d14	Yes	2543835.5	173.3	1.37
2570	0.2	10000	Major	C	450	heb220	90	355	700	8 d25	Yes	3140343.5	160.6	1.30
2571	0.2	10000	Major	S	400	heb260	90	355	500	8 d14	Yes	3595686.5	163.3	1.43
2572	0.2	10000	Major	S	400	heb260	90	355	700	8 d25	Yes	4201670.5	154.9	1.37
2573	0.2	10000	Minor	C	450	heb220	90	355	500	8 d14	Yes	1802300.5	189.8	1.41
2574	0.2	10000	Minor	C	450	heb220	90	355	700	8 d25	Yes	2471614.75	176.2	1.27
2575	0.2	10000	Minor	S	400	heb260	90	355	500	8 d14	Yes	2696926.5	208.2	1.48
2576	0.2	10000	Minor	S	400	heb260	90	355	700	8 d25	Yes	3071623.5	177.8	1.34
2577	0.2	10000	Major	C	450	heb220	90	460	500	8 d14	Yes	2567348.75	172.4	1.34
2578	0.2	10000	Major	C	450	heb220	90	460	700	8 d25	Yes	3152327	160.5	1.28
2579	0.2	10000	Major	S	400	heb260	90	460	500	8 d14	Yes	3709887.5	162.3	1.41
2580	0.2	10000	Major	S	400	heb260	90	460	700	8 d25	Yes	4306164	154.6	1.36
2581	0.2	10000	Minor	C	450	heb220	90	460	500	8 d14	Yes	1818688.375	188.7	1.37
2582	0.2	10000	Minor	C	450	heb220	90	460	700	8 d25	Yes	2478702.75	176.1	1.25
2583	0.2	10000	Minor	S	400	heb260	90	460	500	8 d14	Yes	2411880.25	165.7	1.44
2584	0.2	10000	Minor	S	400	heb260	90	460	700	8 d25	Yes	3121030.5	177.3	1.32
2585	0.2	10000	Major	C	450	heb220	90	550	500	8 d14	Yes	2567348.75	172.4	1.26
2586	0.2	10000	Major	C	450	heb220	90	550	700	8 d25	Yes	3152327	160.5	1.23
2587	0.2	10000	Major	S	400	heb260	90	550	500	8 d14	Yes	3711358.25	162.3	1.37
2588	0.2	10000	Major	S	400	heb260	90	550	700	8 d25	Yes	4307311.5	154.6	1.32
2589	0.2	10000	Minor	C	450	heb220	90	550	500	8 d14	Yes	1818688.375	188.7	1.35
2590	0.2	10000	Minor	C	450	heb220	90	550	700	8 d25	Yes	2478702.75	176.1	1.23
2591	0.2	10000	Minor	S	400	heb260	90	550	500	8 d14	Yes	2411880.25	165.7	1.39
2592	0.2	10000	Minor	S	400	heb260	90	550	700	8 d25	Yes	3121039.75	177.3	1.29
2593	0	4000	Major	C	450	heb220	30	355	500	8 d14	Yes	7861162	21.2	1.49
2594	0	4000	Major	C	450	heb220	30	355	700	8 d25	Yes	10045136	16.6	1.37
2595	0	4000	Major	S	400	heb260	30	355	500	8 d14	Yes	8704116	25.2	1.42
2596	0	4000	Major	S	400	heb260	30	355	700	8 d25	Yes	10866027	15.4	1.34
2597	0	4000	Minor	C	450	heb220	30	355	500	8 d14	Yes	7779148	26.4	1.46
2598	0	4000	Minor	C	450	heb220	30	355	700	8 d25	Yes	10060633	16.6	1.37
2599	0	4000	Minor	S	400	heb260	30	355	500	8 d14	Yes	8495667	26.4	1.42
2600	0	4000	Minor	S	400	heb260	30	355	700	8 d25	Yes	10830530	15.4	1.34
2601	0	4000	Major	C	450	heb220	30	460	500	8 d14	Yes	8929830	21.9	1.45
2602	0	4000	Major	C	450	heb220	30	460	700	8 d25	Yes	11112777	14.9	1.37
2603	0	4000	Major	S	400	heb260	30	460	500	8 d14	Yes	10187209	19.7	1.41
2604	0	4000	Major	S	400	heb260	30	460	700	8 d25	Yes	12320342	13.6	1.34
2605	0	4000	Minor	C	450	heb220	30	460	500	8 d14	Yes	8610732	25.5	1.44
2606	0	4000	Minor	C	450	heb220	30	460	700	8 d25	Yes	10906404	18.4	1.36
2607	0	4000	Minor	S	400	heb260	30	460	500	8 d14	Yes	9679905	25.0	1.41
2608	0	4000	Minor	S	400	heb260	30	460	700	8 d25	Yes	12006650	17.1	1.34
2609	0	4000	Major	C	450	heb220	30	550	500	8 d14	Yes	9607062	14.0	1.40
2610	0	4000	Major	C	450	heb220	30	550	700	8 d25	Yes	11790942	13.0	1.33
2611	0	4000	Major	S	400	heb260	30	550	500	8 d14	Yes	11049122	10.4	1.35
2612	0	4000	Major	S	400	heb260	30	550	700	8 d25	Yes	13203728	10.8	1.30
2613	0	4000	Minor	C	450	heb220	30	550	500	8 d14	Yes	9006552	25.3	1.39
2614	0	4000	Minor	C	450	heb220	30	550	700	8 d25	Yes	11382305	18.4	1.32
2615	0	4000	Minor	S	400	heb260	30	550	500	8 d14	Yes	10252218	25.6	1.36
2616	0	4000	Minor	S	400	heb260	30	550	700	8 d25	Yes	12663070	15.9	1.30
2617	0	4000	Major	C	450	heb220	50	355	500	8 d14	Yes	10321637	19.5	1.55
2618	0	4000	Major	C	450	heb220	50	355	700	8 d25	Yes	12574358	15.8	1.46
2619	0	4000	Major	S	400	heb260	50	355	500	8 d14	Yes	11178702	20.3	1.50
2620	0	4000	Major	S	400	heb260	50	355	700	8 d25	Yes	13391498	18.7	1.41
2621	0	4000	Minor	C	450	heb220	50	355	500	8 d14	Yes	10302118	20.9	1.55

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
2622	0	4000	Minor	C	450	heb220	50	355	700	8 d25	Yes	12583791	15.8	1.46
2623	0	4000	Minor	S	400	heb260	50	355	500	8 d14	Yes	11043662	21.7	1.49
2624	0	4000	Minor	S	400	heb260	50	355	700	8 d25	Yes	13364320	16.7	1.42
2625	0	4000	Major	C	450	heb220	50	460	500	8 d14	Yes	11384212	18.0	1.53
2626	0	4000	Major	C	450	heb220	50	460	700	8 d25	Yes	13583899	15.7	1.44
2627	0	4000	Major	S	400	heb260	50	460	500	8 d14	Yes	12644407	18.2	1.48
2628	0	4000	Major	S	400	heb260	50	460	700	8 d25	Yes	14782018	14.5	1.42
2629	0	4000	Minor	C	450	heb220	50	460	500	8 d14	Yes	11155246	21.4	1.50
2630	0	4000	Minor	C	450	heb220	50	460	700	8 d25	Yes	13437666	16.9	1.43
2631	0	4000	Minor	S	400	heb260	50	460	500	8 d14	Yes	12258560	21.3	1.48
2632	0	4000	Minor	S	400	heb260	50	460	700	8 d25	Yes	14518799	16.3	1.41
2633	0	4000	Major	C	450	heb220	50	550	500	8 d14	Yes	12002956	14.8	1.48
2634	0	4000	Major	C	450	heb220	50	550	700	8 d25	Yes	14226126	13.4	1.41
2635	0	4000	Major	S	400	heb260	50	550	500	8 d14	Yes	13467800	17.6	1.42
2636	0	4000	Major	S	400	heb260	50	550	700	8 d25	Yes	15637186	13.0	1.38
2637	0	4000	Minor	C	450	heb220	50	550	500	8 d14	Yes	11602561	21.4	1.45
2638	0	4000	Minor	C	450	heb220	50	550	700	8 d25	Yes	13894176	16.4	1.39
2639	0	4000	Minor	S	400	heb260	50	550	500	8 d14	Yes	12873332	20.5	1.43
2640	0	4000	Minor	S	400	heb260	50	550	700	8 d25	Yes	15183742	16.1	1.36
2641	0	4000	Major	C	450	heb220	60	355	500	8 d14	Yes	11549550	16.7	1.59
2642	0	4000	Major	C	450	heb220	60	355	700	8 d25	Yes	13849399	15.4	1.49
2643	0	4000	Major	S	400	heb260	60	355	500	8 d14	Yes	12454094	18.8	1.54
2644	0	4000	Major	S	400	heb260	60	355	700	8 d25	Yes	14677904	16.8	1.45
2645	0	4000	Minor	C	450	heb220	60	355	500	8 d14	Yes	11542548	17.2	1.59
2646	0	4000	Minor	C	450	heb220	60	355	700	8 d25	Yes	13858449	15.5	1.49
2647	0	4000	Minor	S	400	heb260	60	355	500	8 d14	Yes	12358595	19.9	1.54
2648	0	4000	Minor	S	400	heb260	60	355	700	8 d25	Yes	14657638	15.9	1.46
2649	0	4000	Major	C	450	heb220	60	460	500	8 d14	Yes	12617907	16.1	1.56
2650	0	4000	Major	C	450	heb220	60	460	700	8 d25	Yes	14858638	14.2	1.47
2651	0	4000	Major	S	400	heb260	60	460	500	8 d14	Yes	13901857	18.1	1.52
2652	0	4000	Major	S	400	heb260	60	460	700	8 d25	Yes	16044620	14.7	1.45
2653	0	4000	Minor	C	450	heb220	60	460	500	8 d14	Yes	12427050	18.2	1.55
2654	0	4000	Minor	C	450	heb220	60	460	700	8 d25	Yes	14732220	16.0	1.46
2655	0	4000	Minor	S	400	heb260	60	460	500	8 d14	Yes	13552844	20.0	1.51
2656	0	4000	Minor	S	400	heb260	60	460	700	8 d25	Yes	15820338	17.3	1.44
2657	0	4000	Major	C	450	heb220	60	550	500	8 d14	Yes	13261032	16.5	1.50
2658	0	4000	Major	C	450	heb220	60	550	700	8 d25	Yes	15484092	14.1	1.43
2659	0	4000	Major	S	400	heb260	60	550	500	8 d14	Yes	14736759	16.3	1.47
2660	0	4000	Major	S	400	heb260	60	550	700	8 d25	Yes	16899064	13.7	1.41
2661	0	4000	Minor	C	450	heb220	60	550	500	8 d14	Yes	12890086	18.4	1.48
2662	0	4000	Minor	C	450	heb220	60	550	700	8 d25	Yes	15202382	16.1	1.42
2663	0	4000	Minor	S	400	heb260	60	550	500	8 d14	Yes	14179932	19.5	1.46
2664	0	4000	Minor	S	400	heb260	60	550	700	8 d25	Yes	16502720	15.8	1.40
2665	0	4000	Major	C	450	heb220	90	355	500	8 d14	Yes	14049505	9.8	1.74
2666	0	4000	Major	C	450	heb220	90	355	700	8 d25	Yes	17650426	10.0	1.62
2667	0	4000	Major	S	400	heb260	90	355	500	8 d14	Yes	16212498	13.1	1.68
2668	0	4000	Major	S	400	heb260	90	355	700	8 d25	Yes	18567344	11.0	1.59
2669	0	4000	Minor	C	450	heb220	90	355	500	8 d14	Yes	14325448	11.2	1.73
2670	0	4000	Minor	C	450	heb220	90	355	700	8 d25	Yes	17767818	10.2	1.62
2671	0	4000	Minor	S	400	heb260	90	355	500	8 d14	Yes	16227308	12.3	1.69
2672	0	4000	Minor	S	400	heb260	90	355	700	8 d25	Yes	18628318	11.8	1.59
2673	0	4000	Major	C	450	heb220	90	460	500	8 d14	Yes	15473124	11.7	1.68
2674	0	4000	Major	C	450	heb220	90	460	700	8 d25	Yes	18717334	10.4	1.58
2675	0	4000	Major	S	400	heb260	90	460	500	8 d14	Yes	17730572	12.3	1.65

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
2676	0	4000	Major	S	400	heb260	90	460	700	8 d25	Yes	20053564	12.0	1.55
2677	0	4000	Minor	C	450	heb220	90	460	500	8 d14	Yes	15500270	12.5	1.67
2678	0	4000	Minor	C	450	heb220	90	460	700	8 d25	Yes	18720360	10.9	1.58
2679	0	4000	Minor	S	400	heb260	90	460	500	8 d14	Yes	17502816	13.7	1.64
2680	0	4000	Minor	S	400	heb260	90	460	700	8 d25	Yes	19872982	11.2	1.56
2681	0	4000	Major	C	450	heb220	90	550	500	8 d14	Yes	16270287	10.6	1.63
2682	0	4000	Major	C	450	heb220	90	550	700	8 d25	Yes	19457512	10.5	1.54
2683	0	4000	Major	S	400	heb260	90	550	500	8 d14	Yes	18639920	11.2	1.59
2684	0	4000	Major	S	400	heb260	90	550	700	8 d25	Yes	20927320	10.3	1.52
2685	0	4000	Minor	C	450	heb220	90	550	500	8 d14	Yes	16026665	12.4	1.61
2686	0	4000	Minor	C	450	heb220	90	550	700	8 d25	Yes	19142292	10.7	1.54
2687	0	4000	Minor	S	400	heb260	90	550	500	8 d14	Yes	18234480	13.8	1.57
2688	0	4000	Minor	S	400	heb260	90	550	700	8 d25	Yes	20559120	12.0	1.51
2689	0.1	4000	Major	C	450	heb220	30	355	500	8 d14	Yes	5208246	34.7	1.45
2690	0.1	4000	Major	C	450	heb220	30	355	700	8 d25	Yes	6658490.5	34.6	1.35
2691	0.1	4000	Major	S	400	heb260	30	355	500	8 d14	Yes	6361884	33.8	1.42
2692	0.1	4000	Major	S	400	heb260	30	355	700	8 d25	Yes	7891215	33.4	1.33
2693	0.1	4000	Minor	C	450	heb220	30	355	500	8 d14	Yes	4449113.5	38.8	1.45
2694	0.1	4000	Minor	C	450	heb220	30	355	700	8 d25	Yes	6161506.5	36.1	1.35
2695	0.1	4000	Minor	S	400	heb260	30	355	500	8 d14	Yes	5502735	38.7	1.42
2696	0.1	4000	Minor	S	400	heb260	30	355	700	8 d25	Yes	7252736.5	37.3	1.33
2697	0.1	4000	Major	C	450	heb220	30	460	500	8 d14	Yes	5869160	33.2	1.44
2698	0.1	4000	Major	C	450	heb220	30	460	700	8 d25	Yes	7353636	32.4	1.35
2699	0.1	4000	Major	S	400	heb260	30	460	500	8 d14	Yes	7385816	30.6	1.41
2700	0.1	4000	Major	S	400	heb260	30	460	700	8 d25	Yes	8894188	32.2	1.33
2701	0.1	4000	Minor	C	450	heb220	30	460	500	8 d14	Yes	4724902	39.7	1.44
2702	0.1	4000	Minor	C	450	heb220	30	460	700	8 d25	Yes	6478850.5	37.4	1.34
2703	0.1	4000	Minor	S	400	heb260	30	460	500	8 d14	Yes	6002891	40.4	1.41
2704	0.1	4000	Minor	S	400	heb260	30	460	700	8 d25	Yes	7795114.5	38.3	1.33
2705	0.1	4000	Major	C	450	heb220	30	550	500	8 d14	Yes	6240749.5	31.5	1.39
2706	0.1	4000	Major	C	450	heb220	30	550	700	8 d25	Yes	7720769	33.8	1.31
2707	0.1	4000	Major	S	400	heb260	30	550	500	8 d14	Yes	7943443.5	31.1	1.35
2708	0.1	4000	Major	S	400	heb260	30	550	700	8 d25	Yes	9443723	28.0	1.29
2709	0.1	4000	Minor	C	450	heb220	30	550	500	8 d14	Yes	4866087.5	40.4	1.40
2710	0.1	4000	Minor	C	450	heb220	30	550	700	8 d25	Yes	6603921.5	35.5	1.30
2711	0.1	4000	Minor	S	400	heb260	30	550	500	8 d14	Yes	6230029	42.6	1.35
2712	0.1	4000	Minor	S	400	heb260	30	550	700	8 d25	Yes	8071027	37.3	1.29
2713	0.1	4000	Major	C	450	heb220	50	355	500	8 d14	Yes	6645969	31.6	1.51
2714	0.1	4000	Major	C	450	heb220	50	355	700	8 d25	Yes	8176701	30.7	1.41
2715	0.1	4000	Major	S	400	heb260	50	355	500	8 d14	Yes	8026462	29.4	1.49
2716	0.1	4000	Major	S	400	heb260	50	355	700	8 d25	Yes	9575135	29.9	1.40
2717	0.1	4000	Minor	C	450	heb220	50	355	500	8 d14	Yes	5912012.5	35.7	1.51
2718	0.1	4000	Minor	C	450	heb220	50	355	700	8 d25	Yes	7653845.5	33.0	1.41
2719	0.1	4000	Minor	S	400	heb260	50	355	500	8 d14	Yes	7132932	37.2	1.49
2720	0.1	4000	Minor	S	400	heb260	50	355	700	8 d25	Yes	8959101	35.0	1.40
2721	0.1	4000	Major	C	450	heb220	50	460	500	8 d14	Yes	7367009.5	31.2	1.49
2722	0.1	4000	Major	C	450	heb220	50	460	700	8 d25	Yes	8875162	29.9	1.40
2723	0.1	4000	Major	S	400	heb260	50	460	500	8 d14	Yes	9079526	29.8	1.47
2724	0.1	4000	Major	S	400	heb260	50	460	700	8 d25	Yes	10565461	29.0	1.39
2725	0.1	4000	Minor	C	450	heb220	50	460	500	8 d14	Yes	6190663.5	35.1	1.50
2726	0.1	4000	Minor	C	450	heb220	50	460	700	8 d25	Yes	7985484.5	34.4	1.40
2727	0.1	4000	Minor	S	400	heb260	50	460	500	8 d14	Yes	7649521	36.1	1.48
2728	0.1	4000	Minor	S	400	heb260	50	460	700	8 d25	Yes	9505315	34.7	1.39
2729	0.1	4000	Major	C	450	heb220	50	550	500	8 d14	Yes	7751386.5	31.0	1.44

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
2730	0.1	4000	Major	C	450	heb220	50	550	700	8 d25	Yes	9244700	30.2	1.37
2731	0.1	4000	Major	S	400	heb260	50	550	500	8 d14	Yes	9623144	29.7	1.41
2732	0.1	4000	Major	S	400	heb260	50	550	700	8 d25	Yes	11136434	26.7	1.35
2733	0.1	4000	Minor	C	450	heb220	50	550	500	8 d14	Yes	6331821.5	36.1	1.46
2734	0.1	4000	Minor	C	450	heb220	50	550	700	8 d25	Yes	8115035.5	34.1	1.36
2735	0.1	4000	Minor	S	400	heb260	50	550	500	8 d14	Yes	7858744.5	37.1	1.43
2736	0.1	4000	Minor	S	400	heb260	50	550	700	8 d25	Yes	9753219	34.2	1.35
2737	0.1	4000	Major	C	450	heb220	60	355	500	8 d14	Yes	7385756.5	29.5	1.53
2738	0.1	4000	Major	C	450	heb220	60	355	700	8 d25	Yes	8891163	28.1	1.43
2739	0.1	4000	Major	S	400	heb260	60	355	500	8 d14	Yes	8868869	28.6	1.52
2740	0.1	4000	Major	S	400	heb260	60	355	700	8 d25	Yes	10342850	27.7	1.43
2741	0.1	4000	Minor	C	450	heb220	60	355	500	8 d14	Yes	6640099.5	32.5	1.53
2742	0.1	4000	Minor	C	450	heb220	60	355	700	8 d25	Yes	8352161.5	31.1	1.43
2743	0.1	4000	Minor	S	400	heb260	60	355	500	8 d14	Yes	7958848	34.0	1.53
2744	0.1	4000	Minor	S	400	heb260	60	355	700	8 d25	Yes	9766731	31.3	1.43
2745	0.1	4000	Major	C	450	heb220	60	460	500	8 d14	Yes	8088494.5	28.1	1.52
2746	0.1	4000	Major	C	450	heb220	60	460	700	8 d25	Yes	9605096	28.6	1.42
2747	0.1	4000	Major	S	400	heb260	60	460	500	8 d14	Yes	9888018	28.5	1.50
2748	0.1	4000	Major	S	400	heb260	60	460	700	8 d25	Yes	11404000	27.7	1.42
2749	0.1	4000	Minor	C	450	heb220	60	460	500	8 d14	Yes	6931718.5	33.7	1.51
2750	0.1	4000	Minor	C	450	heb220	60	460	700	8 d25	Yes	8651601	31.1	1.42
2751	0.1	4000	Minor	S	400	heb260	60	460	500	8 d14	Yes	8491617	34.5	1.51
2752	0.1	4000	Minor	S	400	heb260	60	460	700	8 d25	Yes	10319085	32.5	1.42
2753	0.1	4000	Major	C	450	heb220	60	550	500	8 d14	Yes	8492452	29.3	1.47
2754	0.1	4000	Major	C	450	heb220	60	550	700	8 d25	Yes	9963250	27.8	1.39
2755	0.1	4000	Major	S	400	heb260	60	550	500	8 d14	Yes	10407608	27.5	1.45
2756	0.1	4000	Major	S	400	heb260	60	550	700	8 d25	Yes	11982092	26.6	1.38
2757	0.1	4000	Minor	C	450	heb220	60	550	500	8 d14	Yes	7055899.5	33.1	1.47
2758	0.1	4000	Minor	C	450	heb220	60	550	700	8 d25	Yes	8782159	30.8	1.38
2759	0.1	4000	Minor	S	400	heb260	60	550	500	8 d14	Yes	8712506	33.8	1.46
2760	0.1	4000	Minor	S	400	heb260	60	550	700	8 d25	Yes	10560009	32.0	1.38
2761	0.1	4000	Major	C	450	heb220	90	355	500	8 d14	Yes	9241701	25.1	1.61
2762	0.1	4000	Major	C	450	heb220	90	355	700	8 d25	Yes	10934726	24.1	1.51
2763	0.1	4000	Major	S	400	heb260	90	355	500	8 d14	Yes	11180309	24.3	1.62
2764	0.1	4000	Major	S	400	heb260	90	355	700	8 d25	Yes	12686744	23.8	1.52
2765	0.1	4000	Minor	C	450	heb220	90	355	500	8 d14	Yes	8737459	27.2	1.61
2766	0.1	4000	Minor	C	450	heb220	90	355	700	8 d25	Yes	10497484	26.1	1.51
2767	0.1	4000	Minor	S	400	heb260	90	355	500	8 d14	Yes	10513204	27.2	1.62
2768	0.1	4000	Minor	S	400	heb260	90	355	700	8 d25	Yes	12232215	25.8	1.53
2769	0.1	4000	Major	C	450	heb220	90	460	500	8 d14	Yes	10062299	25.0	1.60
2770	0.1	4000	Major	C	450	heb220	90	460	700	8 d25	Yes	11745032	24.5	1.50
2771	0.1	4000	Major	S	400	heb260	90	460	500	8 d14	Yes	12330509	24.1	1.60
2772	0.1	4000	Major	S	400	heb260	90	460	700	8 d25	Yes	13844225	23.8	1.51
2773	0.1	4000	Minor	C	450	heb220	90	460	500	8 d14	Yes	9027737	26.8	1.58
2774	0.1	4000	Minor	C	450	heb220	90	460	700	8 d25	Yes	10800309	26.1	1.49
2775	0.1	4000	Minor	S	400	heb260	90	460	500	8 d14	Yes	11021818	26.7	1.59
2776	0.1	4000	Minor	S	400	heb260	90	460	700	8 d25	Yes	12782064	25.6	1.51
2777	0.1	4000	Major	C	450	heb220	90	550	500	8 d14	Yes	10353672	24.4	1.55
2778	0.1	4000	Major	C	450	heb220	90	550	700	8 d25	Yes	12031790	23.9	1.47
2779	0.1	4000	Major	S	400	heb260	90	550	500	8 d14	Yes	12842746	23.3	1.55
2780	0.1	4000	Major	S	400	heb260	90	550	700	8 d25	Yes	14387041	23.1	1.47
2781	0.1	4000	Minor	C	450	heb220	90	550	500	8 d14	Yes	9133026	26.5	1.53
2782	0.1	4000	Minor	C	450	heb220	90	550	700	8 d25	Yes	10911073	25.9	1.45
2783	0.1	4000	Minor	S	400	heb260	90	550	500	8 d14	Yes	11302650	27.6	1.53

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Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
2784	0.1	4000	Minor	S	400	heb260	90	550	700	8 d25	Yes	13082294	26.5	1.46
2785	0.2	4000	Major	C	450	heb220	30	355	500	8 d14	Yes	3878962.25	41.3	1.45
2786	0.2	4000	Major	C	450	heb220	30	355	700	8 d25	Yes	5024230	41.2	1.34
2787	0.2	4000	Major	S	400	heb260	30	355	500	8 d14	Yes	5017919	39.2	1.42
2788	0.2	4000	Major	S	400	heb260	30	355	700	8 d25	Yes	6227102	38.7	1.33
2789	0.2	4000	Minor	C	450	heb220	30	355	500	8 d14	Yes	3033539	49.9	1.45
2790	0.2	4000	Minor	C	450	heb220	30	355	700	8 d25	Yes	4426726	48.2	1.34
2791	0.2	4000	Minor	S	400	heb260	30	355	500	8 d14	Yes	3980251.25	52.4	1.41
2792	0.2	4000	Minor	S	400	heb260	30	355	700	8 d25	Yes	5464674	49.5	1.33
2793	0.2	4000	Major	C	450	heb220	30	460	500	8 d14	Yes	4353758.5	42.3	1.43
2794	0.2	4000	Major	C	450	heb220	30	460	700	8 d25	Yes	5517783	40.9	1.34
2795	0.2	4000	Major	S	400	heb260	30	460	500	8 d14	Yes	5773009.5	39.5	1.40
2796	0.2	4000	Major	S	400	heb260	30	460	700	8 d25	Yes	6994268.5	37.6	1.33
2797	0.2	4000	Minor	C	450	heb220	30	460	500	8 d14	Yes	3181533.75	50.8	1.43
2798	0.2	4000	Minor	C	450	heb220	30	460	700	8 d25	Yes	4606727.5	48.3	1.33
2799	0.2	4000	Minor	S	400	heb260	30	460	500	8 d14	Yes	4289552.5	53.0	1.40
2800	0.2	4000	Minor	S	400	heb260	30	460	700	8 d25	Yes	5795813.5	49.6	1.32
2801	0.2	4000	Major	C	450	heb220	30	550	500	8 d14	Yes	4613125.5	43.1	1.38
2802	0.2	4000	Major	C	450	heb220	30	550	700	8 d25	Yes	5769892.5	42.1	1.31
2803	0.2	4000	Major	S	400	heb260	30	550	500	8 d14	Yes	6176018.5	39.6	1.35
2804	0.2	4000	Major	S	400	heb260	30	550	700	8 d25	Yes	7410776	38.6	1.29
2805	0.2	4000	Minor	C	450	heb220	30	550	500	8 d14	Yes	3266973.25	51.4	1.39
2806	0.2	4000	Minor	C	450	heb220	30	550	700	8 d25	Yes	4691023	49.1	1.30
2807	0.2	4000	Minor	S	400	heb260	30	550	500	8 d14	Yes	4424351	53.8	1.35
2808	0.2	4000	Minor	S	400	heb260	30	550	700	8 d25	Yes	5956638	50.3	1.28
2809	0.2	4000	Major	C	450	heb220	50	355	500	8 d14	Yes	4804787	37.3	1.51
2810	0.2	4000	Major	C	450	heb220	50	355	700	8 d25	Yes	5980554	36.6	1.40
2811	0.2	4000	Major	S	400	heb260	50	355	500	8 d14	Yes	6183402.5	37.0	1.48
2812	0.2	4000	Major	S	400	heb260	50	355	700	8 d25	Yes	7426465.5	35.4	1.39
2813	0.2	4000	Minor	C	450	heb220	50	355	500	8 d14	Yes	3849694	42.8	1.51
2814	0.2	4000	Minor	C	450	heb220	50	355	700	8 d25	Yes	5300247	41.9	1.40
2815	0.2	4000	Minor	S	400	heb260	50	355	500	8 d14	Yes	5029271	46.1	1.49
2816	0.2	4000	Minor	S	400	heb260	50	355	700	8 d25	Yes	6536071.5	43.0	1.40
2817	0.2	4000	Major	C	450	heb220	50	460	500	8 d14	Yes	5282650	38.4	1.49
2818	0.2	4000	Major	C	450	heb220	50	460	700	8 d25	Yes	6475739	37.1	1.40
2819	0.2	4000	Major	S	400	heb260	50	460	500	8 d14	Yes	6937997	36.4	1.47
2820	0.2	4000	Major	S	400	heb260	50	460	700	8 d25	Yes	8217677	35.9	1.39
2821	0.2	4000	Minor	C	450	heb220	50	460	500	8 d14	Yes	3998334.25	44.9	1.49
2822	0.2	4000	Minor	C	450	heb220	50	460	700	8 d25	Yes	5458449	42.0	1.39
2823	0.2	4000	Minor	S	400	heb260	50	460	500	8 d14	Yes	5313484	47.0	1.47
2824	0.2	4000	Minor	S	400	heb260	50	460	700	8 d25	Yes	6874059	43.9	1.39
2825	0.2	4000	Major	C	450	heb220	50	550	500	8 d14	Yes	5544523.5	39.4	1.44
2826	0.2	4000	Major	C	450	heb220	50	550	700	8 d25	Yes	6736883	37.4	1.36
2827	0.2	4000	Major	S	400	heb260	50	550	500	8 d14	Yes	7363167.5	37.3	1.41
2828	0.2	4000	Major	S	400	heb260	50	550	700	8 d25	Yes	8623593	35.4	1.35
2829	0.2	4000	Minor	C	450	heb220	50	550	500	8 d14	Yes	4053428.75	44.6	1.46
2830	0.2	4000	Minor	C	450	heb220	50	550	700	8 d25	Yes	5550950	42.8	1.36
2831	0.2	4000	Minor	S	400	heb260	50	550	500	8 d14	Yes	5443607.5	46.7	1.43
2832	0.2	4000	Minor	S	400	heb260	50	550	700	8 d25	Yes	7015267.5	43.7	1.35
2833	0.2	4000	Major	C	450	heb220	60	355	500	8 d14	Yes	5226367.5	36.0	1.52
2834	0.2	4000	Major	C	450	heb220	60	355	700	8 d25	Yes	6429270.5	35.3	1.42
2835	0.2	4000	Major	S	400	heb260	60	355	500	8 d14	Yes	6720817.5	34.7	1.52
2836	0.2	4000	Major	S	400	heb260	60	355	700	8 d25	Yes	7995643.5	34.0	1.42
2837	0.2	4000	Minor	C	450	heb220	60	355	500	8 d14	Yes	4258678.5	42.1	1.53

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Table A.1 – continued from previous page

Index	e_0/d	Length	Axis	Shape	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	Creep	Max Force	u_{ult}	γ_0
2838	0.2	4000	Minor	C	450	heb220	60	355	700	8 d25	Yes	5702640.5	40.6	1.41
2839	0.2	4000	Minor	S	400	heb260	60	355	500	8 d14	Yes	5500467.5	43.2	1.53
2840	0.2	4000	Minor	S	400	heb260	60	355	700	8 d25	Yes	7053439	41.4	1.42
2841	0.2	4000	Major	C	450	heb220	60	460	500	8 d14	Yes	5727621	37.0	1.50
2842	0.2	4000	Major	C	450	heb220	60	460	700	8 d25	Yes	6926972	35.8	1.41
2843	0.2	4000	Major	S	400	heb260	60	460	500	8 d14	Yes	7489894	35.0	1.50
2844	0.2	4000	Major	S	400	heb260	60	460	700	8 d25	Yes	8768975	33.7	1.42
2845	0.2	4000	Minor	C	450	heb220	60	460	500	8 d14	Yes	4396233	41.8	1.51
2846	0.2	4000	Minor	C	450	heb220	60	460	700	8 d25	Yes	5859603.5	40.7	1.40
2847	0.2	4000	Minor	S	400	heb260	60	460	500	8 d14	Yes	5801422.5	43.9	1.50
2848	0.2	4000	Minor	S	400	heb260	60	460	700	8 d25	Yes	7374594	41.3	1.41
2849	0.2	4000	Major	C	450	heb220	60	550	500	8 d14	Yes	5966845	37.2	1.46
2850	0.2	4000	Major	C	450	heb220	60	550	700	8 d25	Yes	7163535.5	36.3	1.38
2851	0.2	4000	Major	S	400	heb260	60	550	500	8 d14	Yes	7910348.5	35.1	1.44
2852	0.2	4000	Major	S	400	heb260	60	550	700	8 d25	Yes	9192141	34.0	1.38
2853	0.2	4000	Minor	C	450	heb220	60	550	500	8 d14	Yes	4441052	42.9	1.46
2854	0.2	4000	Minor	C	450	heb220	60	550	700	8 d25	Yes	5920004.5	40.5	1.37
2855	0.2	4000	Minor	S	400	heb260	60	550	500	8 d14	Yes	5930535.5	43.6	1.45
2856	0.2	4000	Minor	S	400	heb260	60	550	700	8 d25	Yes	7513398	41.1	1.37
2857	0.2	4000	Major	C	450	heb220	90	355	500	8 d14	Yes	6442735.5	31.9	1.60
2858	0.2	4000	Major	C	450	heb220	90	355	700	8 d25	Yes	7694823	31.7	1.49
2859	0.2	4000	Major	S	400	heb260	90	355	500	8 d14	Yes	8282516.5	30.6	1.60
2860	0.2	4000	Major	S	400	heb260	90	355	700	8 d25	Yes	9587221	30.3	1.51
2861	0.2	4000	Minor	C	450	heb220	90	355	500	8 d14	Yes	5388529.5	35.7	1.60
2862	0.2	4000	Minor	C	450	heb220	90	355	700	8 d25	Yes	6810847.5	34.5	1.49
2863	0.2	4000	Minor	S	400	heb260	90	355	500	8 d14	Yes	7009279.5	37.3	1.61
2864	0.2	4000	Minor	S	400	heb260	90	355	700	8 d25	Yes	8572436	35.6	1.51
2865	0.2	4000	Major	C	450	heb220	90	460	500	8 d14	Yes	6912984.5	32.3	1.58
2866	0.2	4000	Major	C	450	heb220	90	460	700	8 d25	Yes	8125483	31.5	1.49
2867	0.2	4000	Major	S	400	heb260	90	460	500	8 d14	Yes	9113656	30.9	1.58
2868	0.2	4000	Major	S	400	heb260	90	460	700	8 d25	Yes	10388364	30.0	1.50
2869	0.2	4000	Minor	C	450	heb220	90	460	500	8 d14	Yes	5549279	36.6	1.56
2870	0.2	4000	Minor	C	450	heb220	90	460	700	8 d25	Yes	6945279.5	34.4	1.47
2871	0.2	4000	Minor	S	400	heb260	90	460	500	8 d14	Yes	7271703.5	37.0	1.58
2872	0.2	4000	Minor	S	400	heb260	90	460	700	8 d25	Yes	8862991	35.5	1.49
2873	0.2	4000	Major	C	450	heb220	90	550	500	8 d14	Yes	7083031	33.0	1.53
2874	0.2	4000	Major	C	450	heb220	90	550	700	8 d25	Yes	8250632	31.3	1.45
2875	0.2	4000	Major	S	400	heb260	90	550	500	8 d14	Yes	9538386	31.2	1.53
2876	0.2	4000	Major	S	400	heb260	90	550	700	8 d25	Yes	10831515	30.4	1.46
2877	0.2	4000	Minor	C	450	heb220	90	550	500	8 d14	Yes	5590467.5	36.4	1.52
2878	0.2	4000	Minor	C	450	heb220	90	550	700	8 d25	Yes	6989676.5	34.3	1.43
2879	0.2	4000	Minor	S	400	heb260	90	550	500	8 d14	Yes	7438807	37.8	1.52
2880	0.2	4000	Minor	S	400	heb260	90	550	700	8 d25	Yes	8994680	35.2	1.44

APPENDIX B: Data from Sectional Analysis to Obtain β_{min} and α_{MN} values

In this appendix, data summarized in sections 7 and 6.3 is presented.

Firstly, in Table B.1, distinct circular sections from Table 7.2 are indexed and obtained β_{min} values for each of them are given.

Finally, in Table B.2, distinct circular and square sections from Table 6.3 are indexed and obtained minimum α_{MN} values for each of them are given. Keys to the letters are listed below.

- C: Circular
- S: Square
- D: Diameter of circular sections and edge length of square sections.

Table B.1: β_{min} Values for Each Distinct Circular Section

Index	**Shape**	**D**	**Profile**	f_{ck}	f_{ak}	f_{sk}	**Rebars**	β_{min}
1	C	450	heb220	30	355	500	8 d14	1.98
2	C	450	heb220	30	355	700	8 d25	1.83
3	C	450	heb220	30	460	500	8 d14	2.08
4	C	450	heb220	30	460	700	8 d25	1.86
5	C	450	heb220	30	550	500	8 d14	2.14
6	C	450	heb220	30	550	700	8 d25	1.87
7	C	450	heb220	60	355	500	8 d14	1.96
8	C	450	heb220	60	355	700	8 d25	1.77
9	C	450	heb220	60	460	500	8 d14	1.99
10	C	450	heb220	60	460	700	8 d25	1.81
11	C	450	heb220	60	550	500	8 d14	1.97
12	C	450	heb220	60	550	700	8 d25	1.79
13	C	450	heb220	90	355	500	8 d14	1.92
14	C	450	heb220	90	355	700	8 d25	1.71
15	C	450	heb220	90	460	500	8 d14	1.94
16	C	450	heb220	90	460	700	8 d25	1.65

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Table B.1 – continued from previous page

Index	**Shape**	**D**	**Profile**	f_{ck}	f_{ak}	f_{sk}	**Rebars**	β_{min}
17	C	450	heb220	90	550	500	8 d14	2.00
18	C	450	heb220	90	550	700	8 d25	1.68
19	C	450	heb220	50	355	500	8 d14	1.99
20	C	450	heb220	50	355	700	8 d25	1.79
21	C	450	heb220	50	460	500	8 d14	2.01
22	C	450	heb220	50	460	700	8 d25	1.86
23	C	450	heb220	50	550	500	8 d14	2.01
24	C	450	heb220	50	550	700	8 d25	1.86
25	C	600	hem300	30	355	500	8 d14	2.25
26	C	600	hem300	30	355	700	8 d25	2.05
27	C	600	hem300	30	550	500	8 d14	2.32
28	C	600	hem300	30	550	700	8 d25	2.11
29	C	600	hem300	90	355	500	8 d14	2.00
30	C	600	hem300	90	355	700	8 d25	1.79
31	C	600	hem300	90	550	500	8 d14	2.14
32	C	600	hem300	90	550	700	8 d25	1.89
33	S	400	heb260	30	355	500	8 d14	1.62
34	S	400	heb260	30	355	700	8 d25	1.56
35	S	400	heb260	30	460	500	8 d14	1.60
36	S	400	heb260	30	460	700	8 d25	1.50
37	S	400	heb260	30	550	500	8 d14	1.51
38	S	400	heb260	30	550	700	8 d25	1.48
39	S	400	heb260	60	355	500	8 d14	1.45
40	S	400	heb260	60	355	700	8 d25	1.40
41	S	400	heb260	60	460	500	8 d14	1.35
42	S	400	heb260	60	460	700	8 d25	1.36
43	S	400	heb260	60	550	500	8 d14	1.27
44	S	400	heb260	60	550	700	8 d25	1.32
45	S	400	heb260	90	355	500	8 d14	1.38
46	S	400	heb260	90	355	700	8 d25	1.32
47	S	400	heb260	90	460	500	8 d14	1.29
48	S	400	heb260	90	460	700	8 d25	1.29
49	S	400	heb260	90	550	500	8 d14	1.21
50	S	400	heb260	90	550	700	8 d25	1.24

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Table B.1 – continued from previous page

Index	**Shape**	**D**	**Profile**	f_{ck}	f_{ak}	f_{sk}	**Rebars**	β_{min}
51	S	400	heb260	50	355	500	8 d14	1.51
52	S	400	heb260	50	355	700	8 d25	1.43
53	S	400	heb260	50	460	500	8 d14	1.41
54	S	400	heb260	50	460	700	8 d25	1.42
55	S	400	heb260	50	550	500	8 d14	1.32
56	S	400	heb260	50	550	700	8 d25	1.38
57	S	500	hem300	30	355	500	8 d14	1.68
58	S	500	hem300	30	355	700	8 d25	1.64
59	S	500	hem300	30	550	500	8 d14	1.47
60	S	500	hem300	30	550	700	8 d25	1.51
61	S	500	hem300	90	355	500	8 d14	1.35
62	S	500	hem300	90	355	700	8 d25	1.35
63	S	500	hem300	90	550	500	8 d14	1.14
64	S	500	hem300	90	550	700	8 d25	1.18

Table B.2: Min α_{MN} Values for Each Distinct Circular and Square Section

Index	**Shape**	**Axis**	**D**	**Profile**	f_{ck}	f_{ak}	f_{sk}	**Rebars**	min α_{MN} for $N_{Ed} <$ 0.5N$_{pl,Rd}$	min α_{MN} for $N_{Ed} \geq$ 0.5N$_{pl,Rd}$
1	C	Strong	450	heb220	30	355	500	8 d14	0.92	0.93
2	C	Strong	450	heb220	30	355	700	8 d25	0.86	0.88
3	C	Weak	450	heb220	30	355	500	8 d14	0.82	0.84
4	C	Weak	450	heb220	30	355	700	8 d25	0.80	0.82
5	C	Strong	450	heb220	30	460	500	8 d14	0.86	0.92
6	C	Strong	450	heb220	30	460	700	8 d25	0.80	0.87
7	C	Weak	450	heb220	30	460	500	8 d14	0.74	0.77
8	C	Weak	450	heb220	30	460	700	8 d25	0.74	0.77
9	C	Strong	450	heb220	30	550	500	8 d14	0.75	0.87
10	C	Strong	450	heb220	30	550	700	8 d25	0.73	0.84
11	C	Weak	450	heb220	30	550	500	8 d14	0.67	0.69
12	C	Weak	450	heb220	30	550	700	8 d25	0.70	0.71
13	C	Strong	450	heb220	60	355	500	8 d14	0.94	0.92

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Table B.2 – continued from previous page

Index	**Shape**	**Axis**	**D**	**Profile**	f_{ck}	f_{ak}	f_{sk}	**Rebars**	min α_{MN} for $N_{Ed} <$ 0.5$N_{pl,Rd}$	min α_{MN} for $N_{Ed} \geq$ 0.5$N_{pl,Rd}$
14	C	Strong	450	heb220	60	355	700	8 d25	0.88	0.88
15	C	Weak	450	heb220	60	355	500	8 d14	0.82	0.86
16	C	Weak	450	heb220	60	355	700	8 d25	0.80	0.84
17	C	Strong	450	heb220	60	460	500	8 d14	0.90	0.92
18	C	Strong	450	heb220	60	460	700	8 d25	0.84	0.88
19	C	Weak	450	heb220	60	460	500	8 d14	0.76	0.80
20	C	Weak	450	heb220	60	460	700	8 d25	0.76	0.79
21	C	Strong	450	heb220	60	550	500	8 d14	0.82	0.87
22	C	Strong	450	heb220	60	550	700	8 d25	0.77	0.85
23	C	Weak	450	heb220	60	550	500	8 d14	0.70	0.74
24	C	Weak	450	heb220	60	550	700	8 d25	0.72	0.74
25	C	Strong	450	heb220	90	355	500	8 d14	0.93	0.92
26	C	Strong	450	heb220	90	355	700	8 d25	0.89	0.88
27	C	Weak	450	heb220	90	355	500	8 d14	0.83	0.87
28	C	Weak	450	heb220	90	355	700	8 d25	0.81	0.85
29	C	Strong	450	heb220	90	460	500	8 d14	0.90	0.92
30	C	Strong	450	heb220	90	460	700	8 d25	0.86	0.88
31	C	Weak	450	heb220	90	460	500	8 d14	0.77	0.82
32	C	Weak	450	heb220	90	460	700	8 d25	0.77	0.81
33	C	Strong	450	heb220	90	550	500	8 d14	0.88	0.87
34	C	Strong	450	heb220	90	550	700	8 d25	0.81	0.86
35	C	Weak	450	heb220	90	550	500	8 d14	0.72	0.77
36	C	Weak	450	heb220	90	550	700	8 d25	0.73	0.76
37	C	Strong	450	heb220	50	355	500	8 d14	0.93	0.93
38	C	Strong	450	heb220	50	355	700	8 d25	0.88	0.88
39	C	Weak	450	heb220	50	355	500	8 d14	0.82	0.86
40	C	Weak	450	heb220	50	355	700	8 d25	0.80	0.84
41	C	Strong	450	heb220	50	460	500	8 d14	0.89	0.92
42	C	Strong	450	heb220	50	460	700	8 d25	0.83	0.88
43	C	Weak	450	heb220	50	460	500	8 d14	0.75	0.80
44	C	Weak	450	heb220	50	460	700	8 d25	0.76	0.79
45	C	Strong	450	heb220	50	550	500	8 d14	0.80	0.88

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Table B.2 – continued from previous page

Index	**Shape**	**Axis**	**D**	**Profile**	f_{ck}	f_{ak}	f_{sk}	**Rebars**	min α_{MN} for $N_{Ed} <$ 0.5N$_{pl,Rd}$	min α_{MN} for $N_{Ed} \geq$ 0.5N$_{pl,Rd}$
46	C	Strong	450	heb220	50	550	700	8 d25	0.76	0.86
47	C	Weak	450	heb220	50	550	500	8 d14	0.69	0.73
48	C	Weak	450	heb220	50	550	700	8 d25	0.71	0.74
49	C	Strong	600	hem300	30	355	500	8 d14	0.94	0.95
50	C	Strong	600	hem300	30	355	700	8 d25	0.92	0.93
51	C	Weak	600	hem300	30	355	500	8 d14	0.79	0.85
52	C	Weak	600	hem300	30	355	700	8 d25	0.79	0.85
53	C	Strong	600	hem300	30	550	500	8 d14	0.73	0.93
54	C	Strong	600	hem300	30	550	700	8 d25	0.73	0.91
55	C	Weak	600	hem300	30	550	500	8 d14	0.59	0.68
56	C	Weak	600	hem300	30	550	700	8 d25	0.62	0.70
57	C	Strong	600	hem300	90	355	500	8 d14	0.94	0.94
58	C	Strong	600	hem300	90	355	700	8 d25	0.92	0.92
59	C	Weak	600	hem300	90	355	500	8 d14	0.80	0.88
60	C	Weak	600	hem300	90	355	700	8 d25	0.80	0.88
61	C	Strong	600	hem300	90	550	500	8 d14	0.80	0.92
62	C	Strong	600	hem300	90	550	700	8 d25	0.79	0.91
63	C	Weak	600	hem300	90	550	500	8 d14	0.64	0.75
64	C	Weak	600	hem300	90	550	700	8 d25	0.66	0.76
65	S	Strong	400	heb260	30	355	500	8 d14	0.97	0.95
66	S	Strong	400	heb260	30	355	700	8 d25	0.94	0.92
67	S	Weak	400	heb260	30	355	500	8 d14	0.88	0.86
68	S	Weak	400	heb260	30	355	700	8 d25	0.89	0.87
69	S	Strong	400	heb260	30	460	500	8 d14	0.93	0.94
70	S	Strong	400	heb260	30	460	700	8 d25	0.92	0.93
71	S	Weak	400	heb260	30	460	500	8 d14	0.81	0.80
72	S	Weak	400	heb260	30	460	700	8 d25	0.84	0.82
73	S	Strong	400	heb260	30	550	500	8 d14	0.89	0.93
74	S	Strong	400	heb260	30	550	700	8 d25	0.88	0.91
75	S	Weak	400	heb260	30	550	500	8 d14	0.74	0.74
76	S	Weak	400	heb260	30	550	700	8 d25	0.79	0.77
77	S	Strong	400	heb260	60	355	500	8 d14	0.97	0.95

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Table B.2 – continued from previous page

Index	Shape	Axis	D	Profile	f_{ck}	f_{ak}	f_{sk}	Rebars	min α_{MN} for $N_{Ed} <$ 0.5N$_{pl,Rd}$	min α_{MN} for $N_{Ed} \geq$ 0.5N$_{pl,Rd}$
78	S	Strong	400	heb260	60	355	700	8 d25	0.94	0.93
79	S	Weak	400	heb260	60	355	500	8 d14	0.88	0.89
80	S	Weak	400	heb260	60	355	700	8 d25	0.88	0.88
81	S	Strong	400	heb260	60	460	500	8 d14	0.94	0.94
82	S	Strong	400	heb260	60	460	700	8 d25	0.92	0.92
83	S	Weak	400	heb260	60	460	500	8 d14	0.82	0.84
84	S	Weak	400	heb260	60	460	700	8 d25	0.84	0.84
85	S	Strong	400	heb260	60	550	500	8 d14	0.91	0.93
86	S	Strong	400	heb260	60	550	700	8 d25	0.89	0.91
87	S	Weak	400	heb260	60	550	500	8 d14	0.76	0.78
88	S	Weak	400	heb260	60	550	700	8 d25	0.80	0.80
89	S	Strong	400	heb260	90	355	500	8 d14	0.97	0.94
90	S	Strong	400	heb260	90	355	700	8 d25	0.94	0.92
91	S	Weak	400	heb260	90	355	500	8 d14	0.88	0.89
92	S	Weak	400	heb260	90	355	700	8 d25	0.88	0.88
93	S	Strong	400	heb260	90	460	500	8 d14	0.95	0.94
94	S	Strong	400	heb260	90	460	700	8 d25	0.92	0.91
95	S	Weak	400	heb260	90	460	500	8 d14	0.83	0.85
96	S	Weak	400	heb260	90	460	700	8 d25	0.84	0.85
97	S	Strong	400	heb260	90	550	500	8 d14	0.92	0.93
98	S	Strong	400	heb260	90	550	700	8 d25	0.89	0.92
99	S	Weak	400	heb260	90	550	500	8 d14	0.77	0.80
100	S	Weak	400	heb260	90	550	700	8 d25	0.80	0.81
101	S	Strong	400	heb260	50	355	500	8 d14	0.97	0.94
102	S	Strong	400	heb260	50	355	700	8 d25	0.94	0.92
103	S	Weak	400	heb260	50	355	500	8 d14	0.87	0.88
104	S	Weak	400	heb260	50	355	700	8 d25	0.88	0.88
105	S	Strong	400	heb260	50	460	500	8 d14	0.94	0.95
106	S	Strong	400	heb260	50	460	700	8 d25	0.92	0.92
107	S	Weak	400	heb260	50	460	500	8 d14	0.82	0.83
108	S	Weak	400	heb260	50	460	700	8 d25	0.84	0.84
109	S	Strong	400	heb260	50	550	500	8 d14	0.90	0.93

Continued on next page

Table B.2 – continued from previous page

Index	**Shape**	**Axis**	**D**	**Profile**	f_{ck}	f_{ak}	f_{sk}	**Rebars**	min α_{MN} for $N_{Ed} <$ 0.5$N_{pl,Rd}$	min α_{MN} for $N_{Ed} \geq$ 0.5$N_{pl,Rd}$
110	S	Strong	400	heb260	50	550	700	8 d25	0.89	0.92
111	S	Weak	400	heb260	50	550	500	8 d14	0.76	0.77
112	S	Weak	400	heb260	50	550	700	8 d25	0.80	0.79
113	S	Strong	500	hem300	30	355	500	8 d14	0.97	0.95
114	S	Strong	500	hem300	30	355	700	8 d25	0.96	0.94
115	S	Weak	500	hem300	30	355	500	8 d14	0.85	0.86
116	S	Weak	500	hem300	30	355	700	8 d25	0.87	0.87
117	S	Strong	500	hem300	30	550	500	8 d14	0.84	0.94
118	S	Strong	500	hem300	30	550	700	8 d25	0.85	0.92
119	S	Weak	500	hem300	30	550	500	8 d14	0.66	0.72
120	S	Weak	500	hem300	30	550	700	8 d25	0.71	0.75
121	S	Strong	500	hem300	90	355	500	8 d14	0.97	0.95
122	S	Strong	500	hem300	90	355	700	8 d25	0.96	0.94
123	S	Weak	500	hem300	90	355	500	8 d14	0.85	0.90
124	S	Weak	500	hem300	90	355	700	8 d25	0.87	0.90
125	S	Strong	500	hem300	90	550	500	8 d14	0.90	0.93
126	S	Strong	500	hem300	90	550	700	8 d25	0.89	0.92
127	S	Weak	500	hem300	90	550	500	8 d14	0.71	0.78
128	S	Weak	500	hem300	90	550	700	8 d25	0.75	0.79

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