

## Requirements for the design of column splices

# Archives Steel Structures

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November 2008 (Corrected version)



## 1 Introduction

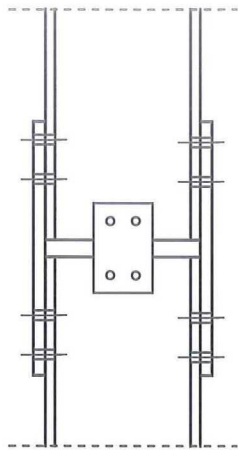
Splices between parts of columns are necessary to keep individual column lengths within manageable dimensions or to provide an opportunity to change the column section. In braced frames, it is current practice to position splices just above floor level so that the overall frame behaviour is not affected. Column splices have to be designed (i) to join the individual lengths in line, (ii) to transmit stresses between the connected members and (iii) to maintain full continuity of stiffness through the connection to safeguard the robustness of the structure.

Columns are predominantly stressed in compression in simple frames. No splice connection is then required, in theory, as the compression forces can be transmitted by direct bearing. However, due to the presence of geometric imperfections (lack of straightness of the column), load eccentricities, and to the fact that even carefully machined surfaces will never guarantee full contact, connections have to be provided. There are two basic types of column splices that may be used: bearing and non-bearing. In both cases, the splices are designed to primarily transmit the compressive load but in different ways. Bearing column splices transfer forces through contact, i.e. direct bearing. Non-bearing column splices transmit the forces through the splice plates and bolts.

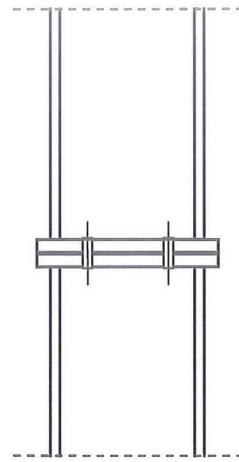
Bolted splice plate and end plate connections are common forms of column splices (Fig. 1.1) [1]. End plate connections provide a convenient and efficient solution to splice columns if the column is subjected to low moments (flush end plates) or high moments (extended end plates) and the splice is located near a point of lateral restraint.

The design philosophy of column splices in current EN 1993-1-8 [2] is based on a continuous joint model whereby the joint is classified as rigid in terms of stiffness to ensure full continuity. In terms of strength, EN 1993-1-8 specifies that the splice material has to transmit the internal forces and any additional forces due to eccentricities or initial imperfections. In the case of non-bearing column splices, the code imposes a minimum requirement for the design moment resistance that is taken as 25% of the moment capacity of the weaker section about both axes [2]. The 25% provision ensures that the splice will not behave as a hinge and also guarantees structural robustness. The need for these restrictions is revisited below.

The overall objective of this research work is to more closely analyse the behaviour of column splices from a strength and stiffness standpoints, as a follow up study of the investigations conducted by Snijder and Hoenderkamp [3,4]. Specific goals of this study are to (i) gain a better understanding of the behaviour of imperfect spliced columns with different end-restraints; (ii) derive a design methodology based on column stability considerations; and (iii) critically assess current design provisions for column splice design. These objectives are addressed through detailed analytical work.



a) Bolted splice plate connection (non-bearing column splice – column ends are not in contact)



b) End plate connection (bearing column splice)

**Fig. 1.1:** Column splices



## 2 Strength design conditions

Strength requirements for the design of column splices are derived below from column stability considerations.

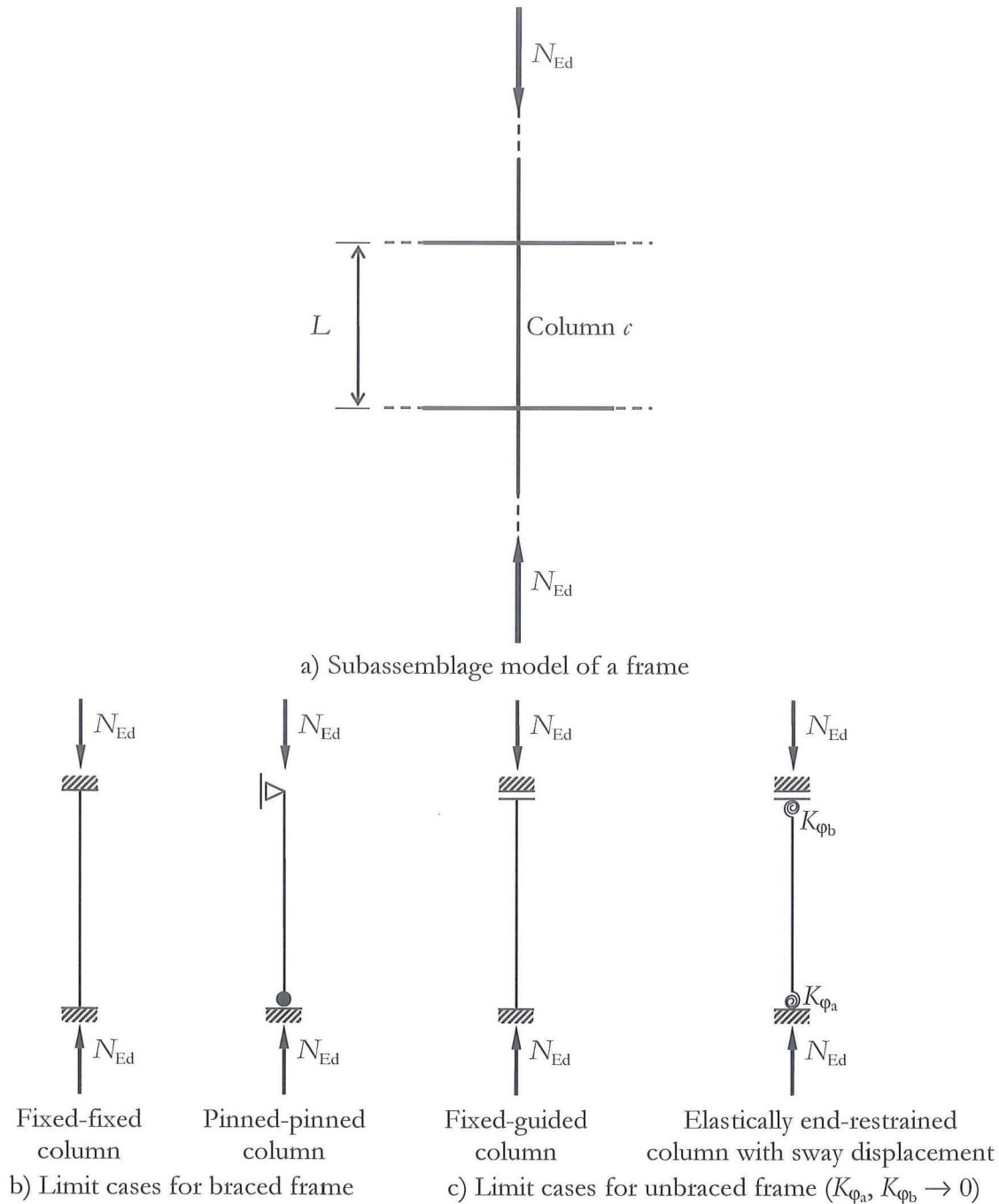
Current frame design procedures are based on the behaviour of individual members, accounting for axial forces and (primary and secondary) bending moments by means of interaction equations that safely combine both internal actions. Additionally, the design of the columns (and splices) take into consideration the effect of the interaction among adjacent framing members, as most columns do not exist as isolated members but as an integral part of a frame. This interaction effect is accounted for by using the effective length, the so-called  $K$ -factor, which is a factor that multiplied by the actual length of the end-restrained column, gives the length of an equivalent simply supported column whose buckling load is the same as the original member [5].

A subassembly model of a frame is illustrated in Fig. 2.1a. Column  $c$  is our concern. If the column is laterally braced (side-sway inhibited), the effective length must always be less than the actual storey height,  $L$ . The two limit cases for frame column modelling are illustrated in Fig. 2.1b. On the other hand, if the column is part of a sway-permitted frame, the effective length is always greater than the actual storey height. The two limit cases considered below are shown in Fig. 2.1c. The  $K$ -factor can be easily determined for these cases [6-8], assuming ideal straight columns. In reality, columns are rarely perfect. Initial lack of straightness is unavoidably present and causes the column to deflect laterally at the onset of loading. This naturally increases the second-order bending moment in the column. To account for this effect, an amplification factor  $A_F$  is defined below [5-8].

Now consider that column  $c$  is spliced at a certain distance  $x = H_{spl}$  from the end. The splice has to be designed in order to guarantee that all the forces are transmitted from one member to the other. Structural design codes specify strength requirements to be fulfilled, even when the column is subjected to simple compression, and full contact in bearing is assumed. According to EN 1993-1-8, if the members are prepared for full contact in bearing, the splice has to transmit at least 25% of the maximum compressive force in the column. Non-bearing column splices have to transmit the internal forces and moments in the member at the spliced section, including the moments due to applied eccentricity, initial imperfections and second-order deformations. In the latter case, the internal forces and moments should be taken as not less than (i) a shear force equal to 2.5% of the normal force capacity of the weaker section in the directions of both axes and (ii) a moment equal to 25% of the moment capacity of the weaker section about both axes. The need for these restrictions is discussed below.

This section presents a practical method for the strength design of (individual) column splices, based on the approach proposed by Snijder and Hoenderkamp [3,4]. The analytical

background to this methodology is also given. Design formulae for axially compressed column splices are derived. Column cross-sections considered below are class 1, 2 or 3 [9]. It is shown that the code requirements regarding the minimum bending moment for splice design can be really severe for common column sections.



**Fig. 2.1:** Structural framed members

## 2.1 Effective length factor for isolated columns

The effective length,  $KL$ , of an end-restrained column is defined as the length of an equivalent pinned-ended column that yields the same critical load as the end-restrained column [6]. For

a centrally loaded end-restrained column, the  $K$ -factor can be evaluated as follows:

$$K = \sqrt{N_e / N_{cr}} \quad (2.1)$$

where:  $N_e$ : Euler load of the pin-ended column having the same length  $L$  as the end-restrained column ( $N_e = \pi^2 EI / L^2$ ;  $E$ : Young's modulus of the material;  $I$ : second moment of area of the cross-section);  
 $N_{cr}$ : critical load of the end-restrained column:

$$N_{cr} = \frac{\pi^2 EI}{(KL)^2} \quad (2.2)$$

The  $K$ -factor values for members in a braced frame and in an unbraced frame are given in Table 2.1, where:

- $v$ : lateral displacement of the column;
- $M_A$ : bending moment at the end of a member;
- $\Delta$ : lateral deflection at the guided end of the column.

The recommended design values are based on realistic column end conditions [6,10]. The limit cases are as follows:

1. For braced frames,  $0.5 \leq K \leq 1.0$  (Fig. 2.1b). The lower bound corresponds to the case where the beams are sufficiently stiff compared to the column, so that the end conditions of the column approach the fixed condition. The upper bound corresponds to the case where the beams are sufficiently weak so that the end conditions of the column approach the pinned condition [5].

2. For unbraced frames,  $1.0 \leq K < \infty$  (Fig. 2.1c). These are theoretical values that correspond to the case where (i) the column is connected to the footing by a fixed support and the far end is rotation fixed ( $K = 1.0$ ) and (ii) the column is connected to the footing by a hinged support and the far end is rotation free and sway displacement is possible ( $K = \infty$ ) [5]. Design practice adopts a minimum value of 1.2 and maximum value of 3.0 for the  $K$ -factor, reflecting the fact that an ideally fixed or hinged support condition is not encountered in a real frame [5]. In this research work,  $K = 2.0$ , corresponding to a perfectly hinged-guided column, is analysed. Other values of the  $K$ -factor in the design of a framed column unbraced against sidesway correspond to those cases with elastic end-restraints, in which some sway displacement is possible. Such cases are most easily solved by using stiffness and carry-over factors [8].

## 2.2 Imperfect column design formula for isolated columns

### 2.2.1 Pin-ended column

Consider a uniform elastic pin-ended column subjected to axial compression  $N_{Ed}$  and with an initial lateral bow imperfection  $v_0(x)$ , with a maximum value  $e_{0,d}$  at mid-span (Fig. 2.2):

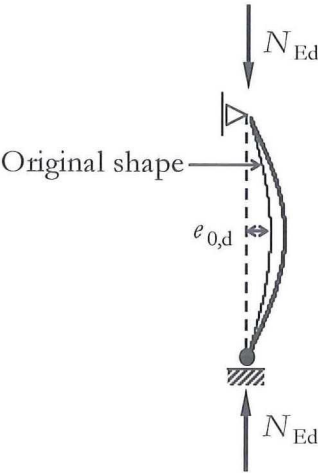
$$v_0(x) = e_{0,d} \sin \frac{\pi x}{L} \quad (2.3)$$

The differential equation that describes the behaviour of this column is written as follows:

$$EI \frac{d^2 v}{dx^2} + N_{Ed} (v + v_0) = 0 \quad (2.4)$$

**Table 2.1:** Theoretical and recommended  $K$ -factor values for idealized columns

| Case                                                                                | Deflection function                                               | $K$ -factor |                          |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------|-------------|--------------------------|
|                                                                                     |                                                                   | Theoretical | Recommended design value |
|    | $v = \frac{M_A}{N_{Ed}} \left( 1 - \cos \frac{2\pi x}{L} \right)$ | 0.5         | 0.65                     |
|    | $v = A \sin \frac{\pi x}{L}$                                      | 1.0         | 1.0                      |
|   | $v = \frac{\Delta}{2} \left( 1 - \cos \frac{\pi x}{L} \right)$    | 1.0         | 1.2                      |
|  | $v = \Delta \sin \frac{\pi x}{2L}$                                | 2.0         | 2.0                      |



**Fig. 2.2:** Pin-ended column with initial lack of straightness



The deflected shape from the initial crooked position of the column is [6-8,11]:

$$v(x) = \frac{N_{Ed}/N_{cr}}{1 - N_{Ed}/N_{cr}} e_{0,d} \sin \frac{\pi x}{L} \quad (2.5)$$

where the critical load  $N_{cr}$  is given by Eq. (2.2). To obtain the total deflection,  $v_{total}(x)$ , from the  $x$  axis, Eq. (2.3) must be added to Eq. (2.5):

$$v_{total}(x) = \frac{1}{1 - \frac{N_{Ed}}{N_{cr}}} e_{0,d} \sin \frac{\pi x}{L} = A_F e_{0,d} \sin \frac{\pi x}{L} = A_F v_0(x) \quad (2.6)$$

Eq. (2.6) states that the total deflection is obtained by multiplying the initial deflection  $v_0(x)$  – Eq. (2.3) – by an amplification factor  $A_F$  given by:

$$A_F = \frac{1}{1 - \frac{N_{Ed}}{N_{cr}}} \quad (2.7)$$

From the equilibrium equation of the column, the bending moment in the column is now:

$$M = N_{Ed} v_{total} = \frac{1}{1 - \frac{N_{Ed}}{N_{cr}}} N_{Ed} e_{0,d} \sin \frac{\pi x}{L} = A_F M_I \quad (2.8)$$

where:  $M_I$ : moment evaluated by considering equilibrium with respect to the original shape of the geometrical imperfect column ( $M_I = N_{Ed} v_0$ ).

The above equation shows that the second-order moment is obtained by multiplying  $M_I$  by the amplification factor.

EN 1993-1-1 [9] adopts a conservative strength criterion for cross-sections subjected to a combination of axial force and in-plane bending moment:

$$\frac{N_{Ed}}{N_{Rd}} + \frac{M_{Ed}}{M_{Rd}} \leq 1 \quad (2.9)$$

in which:  $N_{Rd}$ : design value of the resistance to normal forces (squash load for cross-sections class 1, 2 and 3);

$M_{Ed}$ : design bending moment;

$M_{Rd}$ : design value of the resistance to bending moments.

From the second-order analysis of the most stressed cross-section of the column, the following equation is then derived:

$$\frac{N_{Ed}}{N_{Rd}} + A_F \frac{N_{Ed} e_{0,d}}{M_{Rd}} \leq 1 \quad (2.10)$$

### 2.2.2 End-restrained columns

The extension of the method to deal with other boundary conditions is quite straightforward. For example, consider a prismatic member with fixed-ends that carries an axial compression  $N_{Ed}$ . Suppose that this member is slightly bowed when it is not loaded (Fig. 2.3). The

shape of the unloaded member has the same form of the deflection function of the perfect column (Table 2.1):

$$v_0(x) = \frac{e_{0,d}}{2} \left( 1 - \cos \frac{2\pi x}{L} \right) \quad (2.11)$$

This satisfies the boundary conditions ( $v = v' = 0$  at  $x = 0$  and  $x = L$ ) and it also satisfies  $v_0 = e_{0,d}$  at mid-height of the column. The differential equation for equilibrium of this column is:

$$\frac{d^2 v}{dx^2} + k^2 v = -\frac{V}{EI} x + \frac{M_A}{EI} - k^2 \frac{e_{0,d}}{2} \left( 1 - \cos \frac{2\pi x}{L} \right) \quad (2.12)$$

where:  $V$ : shear force at both ends;  
 $M_A$ : fixed end moment at  $x = 0$ ;  
 $k^2 = N_{Ed}/EI$ ;

and the solution is:

$$v = v_c + v_p \quad (2.13)$$

where:  $v_c$ : complementary solution, which has the following form:

$$v_c = A \sin kx + B \cos kx \quad (2.14)$$

and:  $v_p$ : particular solution of the form:

$$v_p = C \sin \frac{2\pi x}{L} + D \cos \frac{2\pi x}{L} - \frac{Vx}{N_{Ed}} + \frac{M_A}{EI} - \frac{e_{0,d}}{2} \quad (2.15)$$

Substitution of  $v$  for  $v_p$  in Eq. (2.12) gives:

$$C = 0 \quad \text{or} \quad \underbrace{k^2 = \frac{4\pi^2}{L^2}}_{\substack{\text{Critical load} \\ \text{(this is not the relevant solution)}}} \quad (2.16)$$

and:

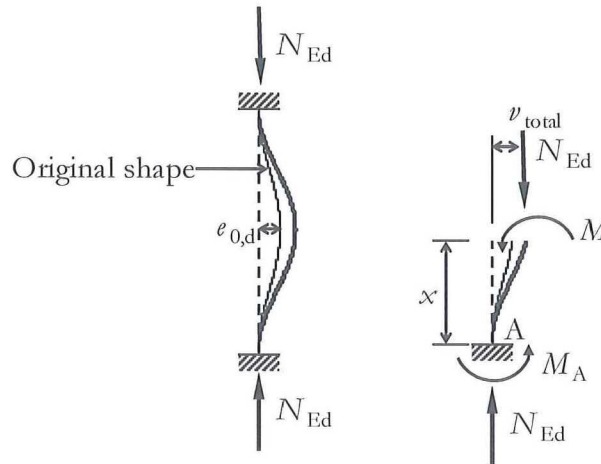


Fig. 2.3: Fixed-fixed column with initial lack of straightness

$$D = \frac{e_{0,d}}{2} \frac{1}{1 - N_{cr}/N_{Ed}} \quad (2.17)$$

Thus:

$$v = A \sin kx + B \cos kx + \frac{e_{0,d}}{2} \frac{1}{1 - N_{cr}/N_{Ed}} \cos \frac{2\pi x}{L} - \frac{Vx}{N_{Ed}} + \frac{M_A}{EI} - \frac{e_{0,d}}{2} \quad (2.18)$$

Because the column will buckle in the symmetric mode, the deflected shape can be obtained by substituting  $V=0$  and  $k=2\pi/L$  into Eq. (2.18) [6,8]. The three unknowns  $A$ ,  $B$  and  $M_A$  are determined from the boundary conditions. For non-trivial solutions:

$$A = 0 \quad B = 0 \quad \frac{M_A}{N_{Ed}} = \frac{1}{1 - \frac{N_{cr}}{N_{Ed}}} \frac{e_{0,d}}{2} = A_F \frac{e_{0,d}}{2} \quad (2.19)$$

The total deflection can then be expressed as:

$$v_{total}(x) = A_F \frac{e_{0,d}}{2} \left( 1 - \cos \frac{2\pi x}{L} \right) = A_F v_0(x) \quad (2.20)$$

which has the same form as Eq. (2.6).

The internal bending moment in the column at a distance  $x$  from end A (Fig. 2.3) is written down as follows:

$$M = N_{Ed} v_{total} - M_A = A_F N_{Ed} v_0 - A_F N_{Ed} \frac{e_{0,d}}{2} = A_F N_{Ed} \left( v_0 - \frac{e_{0,d}}{2} \right) \quad (2.21)$$

whereby  $M_A$  is substituted for Eq. (2.19) and  $v_0$  is given by Eq. (2.11).

Similar reasoning shows that for other end-restrain conditions, the second-order bending moment can be obtained by simply multiplying the moment evaluated by considering equilibrium with respect to the original shape of the geometrical imperfect column by the amplification factor. These results are summarized in Table 2.2 for the four above cases. The assumed initial lack of straightness curves are also indicated.

### 2.3 Column design formula to EN 1993-1-1

The stability design of an axially loaded column to EN 1993-1-1 is based on the concept of *column curves* which give the load-carrying capacity as a function of the column slenderness [9]. The column is then checked according to the following equation:

$$\frac{N_{Ed}}{N_{b,Rd}} \leq 1 \quad (2.22)$$

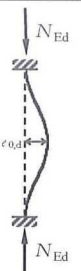
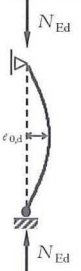
whereby:  $N_{b,Rd}$ : design buckling resistance of the member.

For class 1, 2 and 3 cross-sections, the buckling resistance is taken as:

$$N_{b,Rd} = \frac{\chi A_f}{\gamma_{M1}} \quad (2.23)$$



**Table 2.2:** Bending moment in imperfect columns

| Case                                                                                | Initial lack of straightness curve                                     | Second-order bending moment in the column                                                                                               |
|-------------------------------------------------------------------------------------|------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
|    | $v_0(x) = \frac{e_{0,d}}{2} \left( 1 - \cos \frac{2\pi x}{L} \right)$  | $M(x) = -A_F \frac{N_{Ed} e_{0,d}}{2} \cos \frac{2\pi x}{L}$<br>$A_F = \frac{1}{1 - N_{Ed}/N_{cr}}, N_{cr} = \frac{\pi^2 EI}{(0.5L)^2}$ |
|    | $v_0(x) = e_{0,d} \sin \frac{\pi x}{L}$                                | $M(x) = A_F N_{Ed} e_{0,d} \sin \frac{\pi x}{L}$<br>$A_F = \frac{1}{1 - N_{Ed}/N_{cr}}, N_{cr} = \frac{\pi^2 EI}{L^2}$                  |
|   | $v_0(x) = \frac{e_{0,d}^*}{2} \left( 1 - \cos \frac{\pi x}{L} \right)$ | $M(x) = -A_F \frac{N_{Ed} e_{0,d}^*}{2} \cos \frac{\pi x}{L}$<br>$A_F = \frac{1}{1 - N_{Ed}/N_{cr}}, N_{cr} = \frac{\pi^2 EI}{L^2}$     |
|  | $v_0(x) = e_{0,d}^* \sin \frac{\pi x}{2L}$                             | $M(x) = A_F N_{Ed} e_{0,d}^* \sin \frac{\pi x}{2L}$<br>$A_F = \frac{1}{1 - N_{Ed}/N_{cr}}, N_{cr} = \frac{\pi^2 EI}{(2L)^2}$            |

whereby:  $\chi$ : reduction factor depending on the column slenderness and the relevant buckling curve [9];

$A$ : cross-section area;

$f_y$ : yield strength;

$\gamma_{M1}$ : partial factor for resistance of members to instability assessed by individual member checks (EN 1993-1-1 adopts  $\gamma_{M1} = 1.0$ ).

Because the partial safety coefficients  $\gamma_{M0}$  (partial factor for resistance of cross-sections) and  $\gamma_{M1}$  are set to 1.0 [9], Eq. (2.23) can be re-written as follows:

$$N_{b,Rd} = \chi A f_y = \chi N_{Rd} \quad (2.24)$$

## 2.4 Proposed design methodology

The proposed design methodology in refs. 3 and 4 is based on the assumption that an imperfect spliced column will fail under the combined action of axial force and (secondary) bending moment, according to the criterion given by Eq. (2.9) and realizing that the maximum load a column can carry is given by Eq. (2.22) – and also Eq. (2.24) – according to EN 1993-1-1. Both equations must then be equivalent:

$$\frac{N_{Ed}}{N_{Rd}} + \frac{M_{Ed}}{M_{Rd}} = \frac{N_{Ed}}{\chi N_{Rd}} \quad (2.25)$$

This is basically the methodology already adopted in the literature [3,4,11].  $M_{Ed}$  in Eq. (2.25) represents the maximum second-order moment in the column.

From the above relationships, the maximum amplitude of crookedness,  $e_{0,d,max}$  (or  $e_{0,d,max}^*$ ) can be easily determined. Substitution for these values in the moment equations in Table 2.2 gives the maximum second-order moment at a distance  $x$  from the column end. If  $x$  corresponds to the splice location, then this value will represent the maximum bending moment at the column splice. The procedure is illustrated below for the pin-ended column.

### 2.4.1 Pin-ended column

The maximum secondary moment for an initially crooked column occurs at mid-height and is given by setting  $x = L/2$  in Eq. (2.8):

$$M_{max} = A_F N_{Ed} e_{0,d} \quad (2.26)$$

The maximum amplitude of the initial crookedness is calculated from Eqs. (2.25) and (2.26) by imposing that the maximum resistance is reached at the most severely stressed fibre, i.e. at the mid-height cross-section:

$$\frac{N_{Ed}}{N_{Rd}} + A_F \frac{N_{Ed} e_{0,d,max}}{M_{Rd}} = \frac{N_{Ed}}{\chi N_{Rd}} \quad \Leftrightarrow \quad e_{0,d,max} = \frac{1}{A_F} \frac{1-\chi}{\chi} \frac{M_{Rd}}{N_{Rd}} \quad (2.27)$$

Let  $H_{spl}$  be the splice location (Fig. 2.4). The second-order bending moment at the splice is

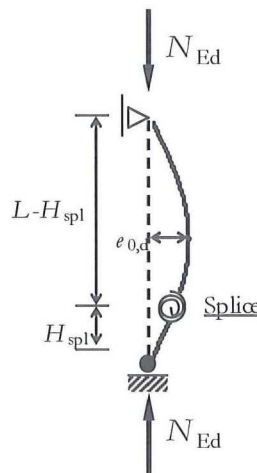


Fig. 2.4: Pin-ended spliced column with initial lack of straightness

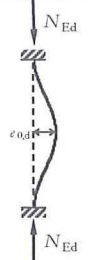
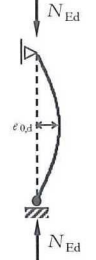
obtained on substituting Eq. (2.27) into Eq. (2.8), for  $\varkappa = H_{\text{spl}}$ :

$$\begin{aligned}
 M_{\text{spl}} &= A_{\text{F}} N_{\text{Ed}} e_{0,\text{d,max}} \sin \frac{\pi H_{\text{spl}}}{L} \quad \Leftrightarrow \quad M_{\text{spl}} = (1 - \chi) \underbrace{\frac{N_{\text{Ed}}}{\chi N_{\text{Rd}}}}_{=1, \text{ from Eqs. (2.22) and (2.24)}} M_{\text{Rd}} \sin \frac{\pi H_{\text{spl}}}{L} \\
 &\quad \Leftrightarrow \quad M_{\text{spl}} = (1 - \chi) M_{\text{Rd}} \sin \frac{\pi H_{\text{spl}}}{L}
 \end{aligned} \tag{2.28}$$

### 2.4.2 End-restrained columns

The extension of this methodology to deal with other column end conditions is straightforward. The principal results are set out in Table 2.3.

**Table 2.3:** Maximum bending moment in the column splice

| Case                                                                                | Maximum second-order bending moment in the column |                                                                          | Maximum amplitude of crookedness                                                                          | Maximum bending moment in the column splice                                     |
|-------------------------------------------------------------------------------------|---------------------------------------------------|--------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
|                                                                                     | Location                                          | Value                                                                    |                                                                                                           |                                                                                 |
|   | Ends                                              | $M_{\text{max}} = A_{\text{F}} \frac{N_{\text{Ed}} e_{0,\text{d}}}{2}$   | $e_{0,\text{d,max}} = \frac{2}{A_{\text{F}}} \frac{1 - \chi}{\chi} \frac{M_{\text{Rd}}}{N_{\text{Rd}}}$   | $M_{\text{spl}} = -(1 - \chi) M_{\text{Rd}} \cos \frac{2\pi H_{\text{spl}}}{L}$ |
|  | Mid-span                                          | $M_{\text{max}} = A_{\text{F}} N_{\text{Ed}} e_{0,\text{d}}$             | $e_{0,\text{d,max}} = \frac{1}{A_{\text{F}}} \frac{1 - \chi}{\chi} \frac{M_{\text{Rd}}}{N_{\text{Rd}}}$   | $M_{\text{spl}} = (1 - \chi) M_{\text{Rd}} \sin \frac{\pi H_{\text{spl}}}{L}$   |
|  | Ends                                              | $M_{\text{max}} = A_{\text{F}} \frac{N_{\text{Ed}} e_{0,\text{d}}^*}{2}$ | $e_{0,\text{d,max}}^* = \frac{2}{A_{\text{F}}} \frac{1 - \chi}{\chi} \frac{M_{\text{Rd}}}{N_{\text{Rd}}}$ | $M_{\text{spl}} = -(1 - \chi) M_{\text{Rd}} \cos \frac{\pi H_{\text{spl}}}{L}$  |
|  | Guided-end                                        | $M_{\text{max}} = A_{\text{F}} N_{\text{Ed}} e_{0,\text{d}}^*$           | $e_{0,\text{d,max}}^* = \frac{1}{A_{\text{F}}} \frac{1 - \chi}{\chi} \frac{M_{\text{Rd}}}{N_{\text{Rd}}}$ | $M_{\text{spl}} = (1 - \chi) M_{\text{Rd}} \sin \frac{\pi H_{\text{spl}}}{2L}$  |

## 2.5 Summary

Column splices have to be designed to transmit the axial load between the connected members and to carry the secondary bending moments summarized in Table 2.3. Splices should be located away from critical sections.

HEA and HEB column sections are taken into account for further comparisons. In order to assess the influence of the splice location over the behaviour of the column in terms of strength design, a simple EXCEL sheet has been prepared by the authors. The main results are summarized in Appendix 1. The following conclusions are drawn:

1. Second-order moments are dominant in slender columns. As the columns become stockier, the effect of second-order moments become less significant.
2. Fixed-fixed columns are conveniently spliced between  $0.2L$  and  $0.3L$  or  $0.7L$  and  $0.8L$ . If the column is spliced at  $0.25L$  or  $0.75L$ , in particular, there is no need to account for second-order bending moments at the splice location as  $M_{\text{splice}} = 0$ . Depending on the column slenderness, the 0.25 factor can be quite conservative.
3. Pin-ended columns are conveniently spliced near the column ends. Depending on the column slenderness and the splice location, the 0.25 factor can be unsafe. For instance, a 8 m HE200A column, made from S355, spliced at 3.2 m from the end ( $0.4L$  – Table A1.18), should be designed for a second-order bending moment equal to  $0.53M_{\text{Rd}}$ .
4. Fixed-guided columns are conveniently spliced at mid-height whereby the second-order bending moments are less significant. Again, depending on the column slenderness and the splice location, the 0.25 factor can be unsafe.
5. Pinned-guided columns are conveniently spliced near the point of effective lateral restraint.

In the author's opinion, the 25% factor should be removed from EN 1993-1-8 and the code should state that the splice should be designed for the actual second-order bending moment, according to Table 2.2. If the design is based upon the design capacity of the column, as a fraction of the bearing capacity from column buckling, assuming that the load will not be larger, then a new limit state for splice design is brought in, as the moment resistance of the splice is limited to  $M_{\text{spl}}$ . The actual factor depends on a number of parameters, namely the column slenderness, the splice location and the boundary conditions.





### 3 Stiffness design conditions

Splices should maintain full continuity of the column stiffness through the connection to ensure structural robustness. According to Bijlaard and Steenhuis [12] and following the approach proposed by Snijder and Hoenderkamp [4], the splice may be classified as rigid if the angles between the connected column members are held virtually unchanged until 95% of the load carrying capacity of an equivalent continuous column has been reached. This criterion is applied below to the Euler buckling load of a spliced column,  $N_{cr, spl-c}$ , to determine a minimum splice stiffness requirement.

The actual rotational stiffness of the splice is evaluated in the context of the component method adopted in EN 1993-1-8.

#### 3.1 Stiffness requirements

Stiffness requirements for a spliced column are derived below from column stability considerations. For the pin-ended and the pinned-guided columns, the problem can be easily solved by analysing and adequately combining the load factors of simple sub-problems, as explained in the following sections. For the other boundary conditions, such a procedure is not conclusive and so the actual system has to be taken into account, as described later in the text.

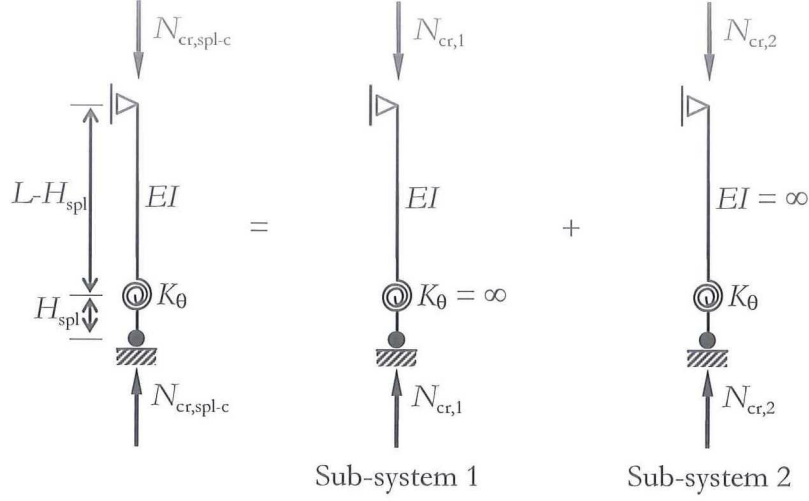
##### 3.1.1 Pin-ended column

The model proposed for the analysis of a spliced column with the above boundary conditions is depicted in Fig. 3.1. In order to derive the critical load of the spliced column, the two sub-systems are analysed [3,4]. The overall system is characterized by two stiffness parameters: the column bending stiffness,  $EI$ , and the splice rotational stiffness,  $K_\theta$ . Such system is simplified into two imaginary sub-systems, whose stiffness parameters are increased up to infinity except the  $i$ -th one, which is kept unchanged. This is the essence of the well-known Föppl-Papkovich theorem [13].

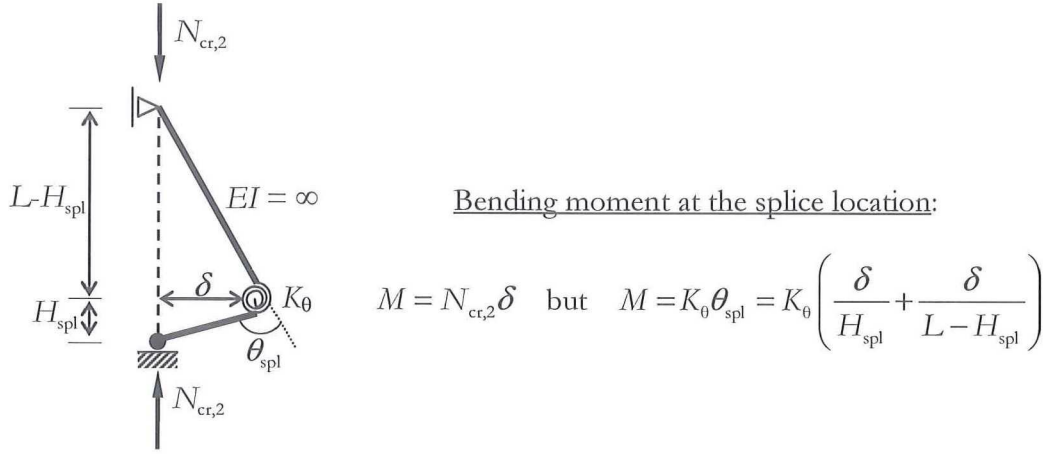
Sub-system 1 is characterized by the Euler buckling load, i.e.:

$$N_{cr,1} = \frac{\pi^2 EI}{L^2} \quad (3.1)$$

Equilibrium analysis of sub-system 2 in the deformed configuration yields the following critical load (see Fig. 3.2):



**Fig. 3.1:** Adopted model for stiffness requirements for the design of a pin-ended column



**Fig. 3.2:** Sub-system 2: deformed configuration (pin-ended column)

$$N_{cr,2} = K_{\theta} \frac{L}{H_{spl} (L - H_{spl})} \quad (3.2)$$

The critical load of the spliced column,  $N_{cr,spl-c}$ , is computed as follows [13]:

$$\frac{1}{N_{cr,spl-c}} = \frac{1}{N_{cr,1}} + \frac{1}{N_{cr,2}} \quad (3.3)$$

If the 5% reduction of the load carrying capacity of the spliced column, compared to the continuous case, is accepted, the following requirement is derived:

$$N_{cr,spl-c} \geq 0.95 N_{cr,1} \quad (3.4)$$

Substitution of the above results in Eq. (3.4) gives:

$$K_{\theta} \geq 19 \frac{H_{spl} (L - H_{spl})}{L} \frac{\pi^2 EI}{L^2} \quad (3.5)$$

### 3.1.2 Pinned-guided column

The model proposed for the analysis of a spliced pinned-guided column is similar to the above model represented in Fig. 3.1. For these boundary conditions, sub-system 1 exhibits the following critical load:

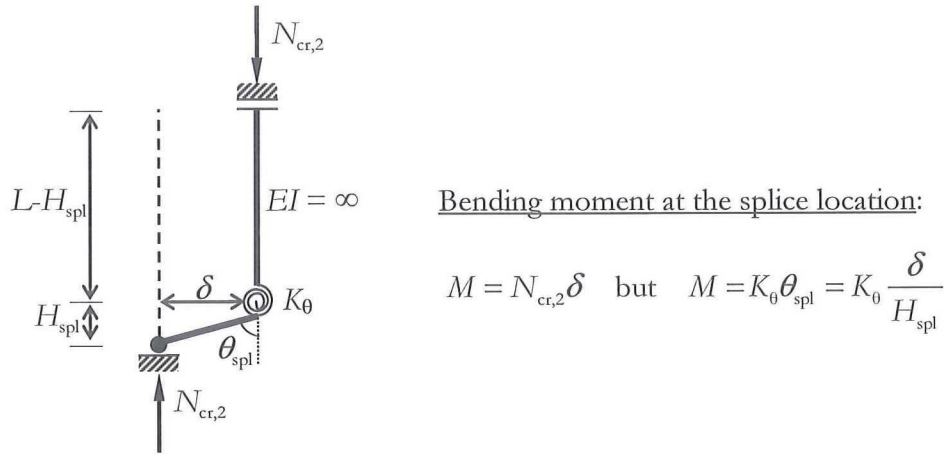
$$N_{cr,1} = \frac{\pi^2 EI}{(2L)^2} \quad (3.6)$$

Equilibrium analysis of sub-system 2 in the deformed configuration now gives (see Fig. 3.3):

$$N_{cr,2} = K_\theta \frac{1}{H_{spl}} \quad (3.7)$$

The requirement for the splice stiffness is readily set up from Eqs. (3.3), (3.4), (3.6) and (3.7):

$$K_\theta \geq 19H_{spl} \frac{\pi^2 EI}{(2L)^2} \quad \text{or} \quad K_\theta \geq 4.75H_{spl} \frac{\pi^2 EI}{L^2} \quad (3.8)$$

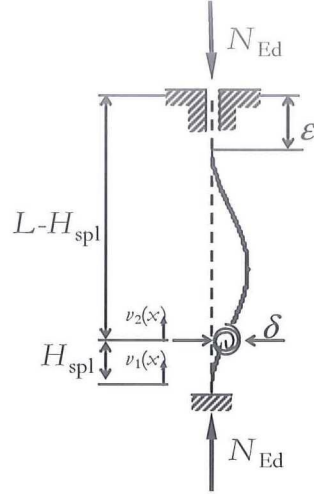


**Fig. 3.3:** Sub-system 2: deformed configuration (pinned-guided column)

### 3.1.3 Fixed-fixed column

The procedure adopted above to set up requirements for the splice stiffness is not appropriate for the analysis of a spliced column with clamped ends. In this case, an energy-based approach is proposed to study the buckling problem and derive the critical load of a column with intermediate rotational spring. The Rayleigh-Ritz method is used to determine an approximate solution of the critical load. In general, the value estimated represents an upper bound solution to the actual critical load. In this method, a deflected shape function that satisfies the kinematic boundary conditions of the member is assumed. The principle of stationary total potential energy is then applied to establish the necessary solutions of the problem.

Consider the structural system depicted in Fig. 3.4. The system has two segments of lengths  $H_{spl}$  and  $L-H_{spl}$ . A rotational spring joins the two segments.  $K_\theta$  is the rotational stiffness of the spring. By means of an energy formulation, the following total potential function,  $V$  is obtained for the above system:



**Fig. 3.4:** Spliced column with fixed ends

$$V = \frac{1}{2} K_{\theta} \theta_{\text{spl}}^2 + \frac{1}{2} \int_0^{H_{\text{spl}}} EI \left( \frac{d^2 v_1}{dx^2} \right)^2 dx + \frac{1}{2} \int_0^{L-H_{\text{spl}}} EI \left( \frac{d^2 v_2}{dx^2} \right)^2 dx - N_{\text{Ed}} \varepsilon \quad (3.9)$$

whereby:  $\theta_{\text{spl}}$ : spring rotation, given by:

$$\theta_{\text{spl}} = \left( \frac{dv_2}{dx} \right)_{(x=0)} - \left( \frac{dv_1}{dx} \right)_{(x=H_{\text{spl}})} \quad (3.10)$$

$v_i$ : deflection curve for segment  $i$ ;

$\varepsilon$ : column shortening due to the axial load, given by:

$$\varepsilon = \frac{1}{2} \int_0^{H_{\text{spl}}} \left( \frac{dv_1}{dx} \right)^2 dx + \frac{1}{2} \int_0^{L-H_{\text{spl}}} \left( \frac{dv_2}{dx} \right)^2 dx \quad (3.11)$$

Now, consider that the buckling mode of the system is approximated by the following function:

$$\begin{aligned} \bar{v}_1 &= a_1 \left( \frac{x}{H_{\text{spl}}} \right)^2 & \text{for segment 1} & \quad 0 \leq x \leq H_{\text{spl}} \\ \bar{v}_2 &= a_2 \left( \frac{L-H_{\text{spl}}-x}{L-H_{\text{spl}}} \right)^2 & \text{for segment 2} & \quad 0 \leq x \leq L-H_{\text{spl}} \end{aligned} \quad (3.12)$$

which satisfies the boundary and continuity conditions,  $a_i$  being undetermined coefficients that are equal to the lateral displacement at the spring location  $\delta$

$$\begin{aligned} \bar{v}_1(0) &= 0 & \text{and} & \quad \bar{v}_1'(0) = 0 \\ \bar{v}_2(L-H_{\text{spl}}) &= 0 & \text{and} & \quad \bar{v}_2'(L-H_{\text{spl}}) = 0 \\ \bar{v}_1'(H_{\text{spl}}) &\neq 0 & \text{and} & \quad \bar{v}_2'(0) \neq 0 \\ \bar{v}_1(H_{\text{spl}}) &= \bar{v}_2(0) = \delta & \Rightarrow & \quad a_1 = a_2 = \delta \end{aligned} \quad (3.13)$$

The potential energy function defined in Eq. (3.9) is now written as:

$$V = \delta \left\{ K_0 \left[ \frac{L}{H_{\text{spl}}(L - H_{\text{spl}})} \right]^2 + EI \left[ \left( \frac{1}{H_{\text{spl}}} \right)^3 + \left( \frac{1}{L - H_{\text{spl}}} \right)^3 \right] - \frac{N_{\text{Ed}}}{3} \left( \frac{1}{H_{\text{spl}}} + \frac{1}{L - H_{\text{spl}}} \right) \right\} \quad (3.14)$$

on substituting  $v_i$  for Eq. (3.12). The critical load of the system,  $N_{\text{cr,spl-c}}$ , is obtained on differentiating the above function twice, with respect to the degree of freedom  $\delta$ , and equating to zero:

$$\frac{d^2V}{d\delta^2} = 0 \quad \Leftrightarrow \quad N_{\text{cr,spl-c}} = \frac{3}{H_{\text{spl}}(L - H_{\text{spl}})} \left[ K_0 L + EI \frac{L^2 - 3LH_{\text{spl}} + 3H_{\text{spl}}^2}{H_{\text{spl}}(L - H_{\text{spl}})} \right] \quad (3.15)$$

The critical load of the continuous perfect system is defined as follows (c.f. §2.1):

$$N_{\text{cr}} = \frac{\pi^2 EI}{(0.5L)^2} \quad (3.16)$$

Application of the 5% criterion expressed in Eq. (3.4) gives:

$$N_{\text{cr,spl-c}} \geq 0.95 N_{\text{cr}} \quad (3.17)$$

By using Eqs. (3.15), (3.16) and (3.17), the stiffness requirement is thus defined as follows:

$$K_0 \geq \frac{EI}{L} \left[ \frac{19}{15} \frac{\pi^2 H_{\text{spl}}(L - H_{\text{spl}})}{L^2} - \frac{L^2 - 3LH_{\text{spl}} + 3H_{\text{spl}}^2}{H_{\text{spl}}(L - H_{\text{spl}})} \right] \quad (3.18)$$

If this criterion is not taken into account, then the following inequality has to be fulfilled:

$$N_{\text{cr,spl-c}} \geq N_{\text{cr}} \quad (3.19)$$

and, so:

$$K_0^* \geq \frac{EI}{L} \left[ \frac{4}{3} \frac{\pi^2 H_{\text{spl}}(L - H_{\text{spl}})}{L^2} - \frac{L^2 - 3LH_{\text{spl}} + 3H_{\text{spl}}^2}{H_{\text{spl}}(L - H_{\text{spl}})} \right] \quad (3.20)$$

### 3.1.4 Fixed-guided column

The analysis of a fixed-guided spliced column is identical to the above. The following functions are now used to approximate the buckling mode:

$$\begin{aligned} \bar{v}_1 &= a_1 \left( \frac{x}{H_{\text{spl}}} \right)^2 & \text{for segment 1} & \quad 0 \leq x \leq H_{\text{spl}} \\ \bar{v}_2 &= \Delta - a_2 \left( \frac{L - H_{\text{spl}} - x}{L - H_{\text{spl}}} \right)^2 & \text{for segment 2} & \quad 0 \leq x \leq L - H_{\text{spl}} \end{aligned} \quad (3.21)$$

that satisfies the boundary conditions:



$$\begin{aligned}\bar{v}_1(0) &= 0 & \text{and} & \quad \bar{v}_1'(0) = 0 \\ \bar{v}_2(L - H_{\text{spl}}) &= \Delta & \text{and} & \quad \bar{v}_2'(L - H_{\text{spl}}) = 0\end{aligned}\quad (3.22)$$

$\Delta$  being the transverse displacement at the guided end. The undetermined coefficients  $a_1$  and  $a_2$  are readily determined from the continuity conditions:

$$\bar{v}_1(H_{\text{spl}}) = \bar{v}_2(0) = \delta \quad \Rightarrow \quad a_1 = \Delta - a_2 = \delta \quad (3.23)$$

where, again  $\delta$  is the lateral displacement at the spring location.

The general potential function for a spliced column expressed in Eq. (3.9) is written as follows:

$$V = 2K_0 \left( \frac{1}{L - H_{\text{spl}}} \right)^2 \left( \Delta - \delta \frac{L}{H_{\text{spl}}} \right)^2 + 2EI \left[ \frac{\delta^2}{H_{\text{spl}}^3} + \frac{(\Delta - \delta)^2}{(L - H_{\text{spl}})^3} \right] - \frac{2N_{\text{Ed}}}{3} \left[ \frac{\delta^2}{H_{\text{spl}}} + \frac{(\Delta - \delta)^2}{L - H_{\text{spl}}} \right] \quad (3.24)$$

The system now has two degrees-of-freedom,  $\delta$  and  $\Delta$ . The equilibrium equations of the system are determined by differentiation of the above function with respect to the two degrees-of-freedom and setting the resulting function as equal to zero:

$$\frac{\partial V}{\partial \delta} = 0 \quad \text{and} \quad \frac{\partial V}{\partial \Delta} = 0 \quad (3.25)$$

The above equations are written down in matrix form:

$$\begin{bmatrix} K_0(L - H_{\text{spl}}) + EI - \frac{N_{\text{Ed}}}{3}(L - H_{\text{spl}})^2 & -K_0(L - H_{\text{spl}})\frac{L}{H_{\text{spl}}} + EI - \frac{N_{\text{Ed}}}{3}(L - H_{\text{spl}})^2 \\ -K_0LH_{\text{spl}}^2(L - H_{\text{spl}}) + \frac{N_{\text{Ed}}}{3}H_{\text{spl}}^3(L - H_{\text{spl}})^2 & K_0L^2H_{\text{spl}}(L - H_{\text{spl}}) + EI[(L - H_{\text{spl}})^3 - H_{\text{spl}}^3] - \frac{N_{\text{Ed}}}{3}LH_{\text{spl}}^2(L - H_{\text{spl}})^2 \end{bmatrix} \begin{bmatrix} \Delta \\ \delta \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} \quad (3.26)$$

For nontrivial solution, the determinant of the above matrix must be set equal to zero, from which the two eigenvalues are:

$$\begin{aligned}N_{\text{cr,spl-c}} &= \pm \frac{3}{2H_{\text{spl}}^2(L - H_{\text{spl}})^2} \left[ K_0LH_{\text{spl}}(L - H_{\text{spl}}) + EI[H_{\text{spl}}^2 + (L - H_{\text{spl}})^2] \right] + \\ &+ \sqrt{\left[ K_0LH_{\text{spl}}(L - H_{\text{spl}}) \right]^2 + (EI)^2 L^2 (L - 2H_{\text{spl}})^2 + 2EIK_0LH_{\text{spl}}(L - H_{\text{spl}})(L - 2H_{\text{spl}})^2} \end{aligned} \quad (3.27)$$

The critical load of the continuous perfect system is now defined as follows (c.f. §2.1):

$$N_{\text{cr}} = \frac{\pi^2 EI}{L^2} \quad (3.28)$$

Application of the inequality expressed in Eq. (3.19) and Eqs. (3.27) and (3.28), the stiffness requirement is defined as follows:

$$K_0' \geq EI \left[ \frac{206088L - 381915H_{\text{spl}}\frac{H_{\text{spl}}}{L} + 1948189H_{\text{spl}}\left(\frac{H_{\text{spl}}}{L}\right)^2 - 974091H_{\text{spl}}\left(\frac{H_{\text{spl}}}{L}\right)^3 - 592176H_{\text{spl}}}{90000L^2 - 296088H_{\text{spl}}(L - H_{\text{spl}})} \right] \quad (3.29)$$

### 3.2 Available splice stiffness

The available stiffness of a column splice is determined below in the framework of the component method [2,14]. Two situations are taken into account: either the splice is subjected to compressive stresses only or the splice is subjected to a combination of tensile and compressive stresses.

#### 3.2.1 Rotational stiffness of a compressed spliced column

For small load eccentricities, the end plate that splices the column is subjected to compressive stresses only, i.e. the bending stresses are small compared to the axial stresses. This means that the centre of compression is located inside the core of section. For an I-section, the core is defined as in Fig. 3.5. In this case, the splice provides full continuity of stiffness. Take the spliced column illustrated in Fig. 3.6 as an example. Consider that the splice configuration is identical to that depicted in Fig. 1.1b. In this case, the stiffness of the continuous column, over a length equal to the thickness of the two end plates, is identical to the splice stiffness (probably even lower because of the splice material).

If the column splice is subjected to compression only, the individual stiffness of the bolts in compression can be taken as infinite. Then the only active component is the end plate in compression (epc), with stiffness:

$$k_{epc} = \frac{A_{ep}}{t_{ep,u} + t_{ep,l}} \quad (3.30)$$

whereby:  $k_{epc}$ : stiffness coefficient of the component end plate in compression;  
 $A_{ep}$ : area of the end plate;  
 $t_{ep,u/l}$ : thickness of the upper (u) or lower end plate (l).

Conservatively, the above expression may adopt the cross-section area of the column,  $A_c$ , instead of the plate area:

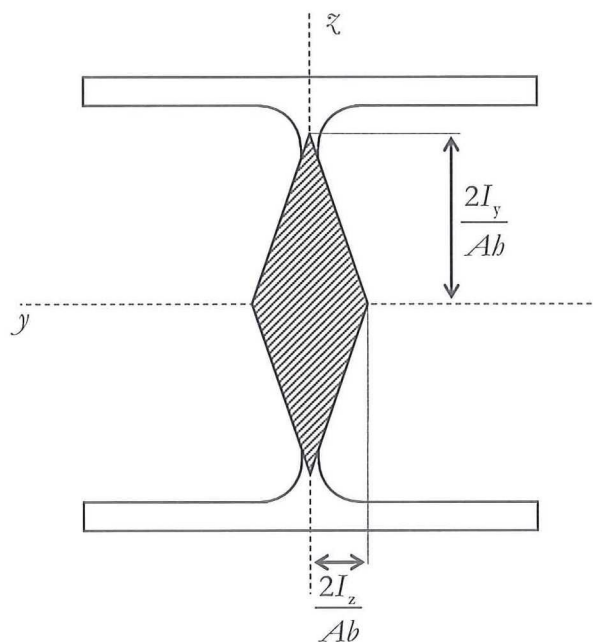
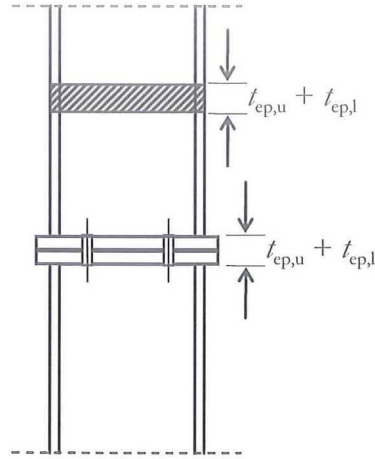


Fig. 3.5: Core of an I-section profile



**Fig. 3.6:** Compressed splice column

$$k_{epc} = \frac{A_c}{t_{ep,u} + t_{ep,l}} \quad (3.31)$$

This is exactly the same stiffness of a continuous column with a length of  $t_{ep,u} + t_{ep,l}$ . Therefore, in the case of spliced columns subjected to compression only, full continuity of stiffness is ensured.

### 3.2.2 Rotational stiffness of a spliced column subjected to a combination of tensile and compressive stresses

For larger load eccentricities, the end plate that splices the column is subjected to a combination of tensile and compressive stresses. The splice may be treated as a beam-column end plate connection with respect to stiffness computations. EN 1993-1-8 gives rules for the evaluation of the initial stiffness in this case *provided that the axial force  $N_{Ed}$  in the connected member does not exceed 5% of the design resistance of its cross-section* [2]. Extension of this methodology for any  $M$ - $N$  joint interaction can be found in literature [15,16].

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## Appendix 1

This appendix to section 2 evaluates the ratio  $M_{spl}/M_{rd}$  for different column lengths ( $L = 4$  m, 6 m and 8 m) and different splice locations. HEA and HEB column sections are taken into account for comparisons. Table A1.1 summarizes the section profiles properties. Table A1.2 evaluates the column slenderness for a column height of 4 m and for different steel grades. The four boundary conditions from Fig. 2.1 are considered. The  $K$ -factor is taken from Table 2.1, for ideal and design conditions. Tables A1.3 through A1.7 set out the above ratio for different splice locations. The following Tables A1.8 through A1.20 give identical values for different column lengths.

**Table A1.1:** HE section profiles properties

| Section | $h$<br>(mm) | $b$<br>(mm) | $h/b$ | $A$<br>(mm <sup>2</sup> ) | $I_y$<br>(mm <sup>4</sup> ) | $W_{el,y}$<br>(mm <sup>3</sup> ) | $W_{pl,y}$<br>(mm <sup>3</sup> ) | Class (pure compression) |      |      | Axial Resistance,<br>$N_{Rd}$ (N) |          |          | Bending Resistance<br>$M_{Rd}$ (Nmm) |          |          |
|---------|-------------|-------------|-------|---------------------------|-----------------------------|----------------------------------|----------------------------------|--------------------------|------|------|-----------------------------------|----------|----------|--------------------------------------|----------|----------|
|         |             |             |       |                           |                             |                                  |                                  | S235                     | S355 | S460 | S235                              | S355     | S460     | S235                                 | S355     | S460     |
| HE100A  | 96          | 100         | 0.96  | 2120                      | 3.49E+06                    | 7.28E+04                         | 8.30E+04                         | 1                        | 1    | 1    | 4.98E+05                          | 7.53E+05 | 9.75E+05 | 1.95E+07                             | 2.95E+07 | 3.82E+07 |
| HE100B  | 100         | 100         | 1.00  | 2600                      | 4.50E+06                    | 8.99E+04                         | 1.04E+05                         | 1                        | 1    | 1    | 6.11E+05                          | 9.23E+05 | 1.20E+06 | 2.45E+07                             | 3.70E+07 | 4.79E+07 |
| HE120A  | 114         | 120         | 0.95  | 2530                      | 6.06E+06                    | 1.06E+05                         | 1.20E+05                         | 1                        | 1    | 2    | 5.95E+05                          | 8.98E+05 | 1.16E+06 | 2.81E+07                             | 4.24E+07 | 5.50E+07 |
| HE120B  | 120         | 120         | 1.00  | 3400                      | 8.64E+06                    | 1.44E+05                         | 1.65E+05                         | 1                        | 1    | 1    | 7.99E+05                          | 1.21E+06 | 1.56E+06 | 3.88E+07                             | 5.86E+07 | 7.60E+07 |
| HE140A  | 133         | 140         | 0.95  | 3140                      | 1.03E+07                    | 1.55E+05                         | 1.74E+05                         | 1                        | 2    | 3    | 7.38E+05                          | 1.11E+06 | 1.44E+06 | 4.08E+07                             | 6.16E+07 | 7.15E+07 |
| HE140B  | 140         | 140         | 1.00  | 4300                      | 1.51E+07                    | 2.16E+05                         | 2.45E+05                         | 1                        | 1    | 1    | 1.01E+06                          | 1.53E+06 | 1.98E+06 | 5.77E+07                             | 8.71E+07 | 1.13E+08 |
| HE160A  | 152         | 160         | 0.95  | 3880                      | 1.67E+07                    | 2.20E+05                         | 2.45E+05                         | 1                        | 2    | 3    | 9.12E+05                          | 1.38E+06 | 1.78E+06 | 5.76E+07                             | 8.70E+07 | 1.01E+08 |
| HE160B  | 160         | 160         | 1.00  | 5430                      | 2.49E+07                    | 3.12E+05                         | 3.54E+05                         | 1                        | 1    | 1    | 1.28E+06                          | 1.93E+06 | 2.50E+06 | 8.32E+07                             | 1.26E+08 | 1.63E+08 |
| HE180A  | 171         | 180         | 0.95  | 4530                      | 2.51E+07                    | 2.94E+05                         | 3.25E+05                         | 1                        | 3    | 3    | 1.06E+06                          | 1.61E+06 | 2.08E+06 | 7.64E+07                             | 1.04E+08 | 1.35E+08 |
| HE180B  | 180         | 180         | 1.00  | 6530                      | 3.83E+07                    | 4.26E+05                         | 4.81E+05                         | 1                        | 1    | 1    | 1.53E+06                          | 2.32E+06 | 3.00E+06 | 1.13E+08                             | 1.71E+08 | 2.21E+08 |
| HE200A  | 190         | 200         | 0.95  | 5380                      | 3.69E+07                    | 3.89E+05                         | 4.30E+05                         | 1                        | 3    | 3    | 1.26E+06                          | 1.91E+06 | 2.47E+06 | 1.01E+08                             | 1.38E+08 | 1.79E+08 |
| HE200B  | 200         | 200         | 1.00  | 7810                      | 5.70E+07                    | 5.70E+05                         | 6.43E+05                         | 1                        | 1    | 1    | 1.84E+06                          | 2.77E+06 | 3.59E+06 | 1.51E+08                             | 2.28E+08 | 2.96E+08 |
| HE220A  | 210         | 220         | 0.95  | 6430                      | 5.41E+07                    | 5.15E+05                         | 5.69E+05                         | 1                        | 3    | 3    | 1.51E+06                          | 2.28E+06 | 2.96E+06 | 1.34E+08                             | 1.83E+08 | 2.37E+08 |
| HE220B  | 220         | 220         | 1.00  | 9100                      | 8.09E+07                    | 7.36E+05                         | 8.27E+05                         | 1                        | 1    | 1    | 2.14E+06                          | 3.23E+06 | 4.19E+06 | 1.94E+08                             | 2.94E+08 | 3.80E+08 |
| HE240A  | 230         | 240         | 0.96  | 7680                      | 7.76E+07                    | 6.75E+05                         | 7.45E+05                         | 1                        | 3    | 3    | 1.80E+06                          | 2.73E+06 | 3.53E+06 | 1.75E+08                             | 2.40E+08 | 3.11E+08 |
| HE240B  | 240         | 240         | 1.00  | 10600                     | 1.13E+08                    | 9.38E+05                         | 1.05E+06                         | 1                        | 1    | 1    | 2.49E+06                          | 3.76E+06 | 4.88E+06 | 2.47E+08                             | 3.74E+08 | 4.84E+08 |
| HE260A  | 250         | 260         | 0.96  | 8680                      | 1.05E+08                    | 8.36E+05                         | 9.20E+05                         | 2                        | 3    | 3    | 2.04E+06                          | 3.08E+06 | 3.99E+06 | 2.16E+08                             | 2.97E+08 | 3.85E+08 |
| HE260B  | 260         | 260         | 1.00  | 11840                     | 1.49E+08                    | 1.15E+06                         | 1.28E+06                         | 1                        | 1    | 2    | 2.78E+06                          | 4.20E+06 | 5.45E+06 | 3.02E+08                             | 4.55E+08 | 5.90E+08 |
| HE280A  | 270         | 280         | 0.96  | 9730                      | 1.37E+08                    | 1.01E+06                         | 1.11E+06                         | 2                        | 3    | 4    | 2.29E+06                          | 3.45E+06 |          | 2.61E+08                             | 3.60E+08 |          |
| HE280B  | 280         | 280         | 1.00  | 13140                     | 1.93E+08                    | 1.38E+06                         | 1.53E+06                         | 1                        | 1    | 2    | 3.09E+06                          | 4.66E+06 | 6.04E+06 | 3.60E+08                             | 5.45E+08 | 7.06E+08 |
| HE300A  | 290         | 300         | 0.97  | 11250                     | 1.83E+08                    | 1.26E+06                         | 1.38E+06                         | 2                        | 3    | 3    | 2.64E+06                          | 3.99E+06 | 5.18E+06 | 3.25E+08                             | 4.47E+08 | 5.80E+08 |
| HE300B  | 300         | 300         | 1.00  | 14910                     | 2.52E+08                    | 1.68E+06                         | 1.87E+06                         | 1                        | 3    | 3    | 3.50E+06                          | 5.29E+06 | 6.86E+06 | 4.39E+08                             | 5.96E+08 | 7.72E+08 |
| HE320A  | 310         | 300         | 1.03  | 12440                     | 2.29E+08                    | 1.48E+06                         | 1.63E+06                         | 1                        | 3    | 3    | 2.92E+06                          | 4.42E+06 | 5.72E+06 | 3.83E+08                             | 5.25E+08 | 6.80E+08 |
| HE320B  | 320         | 300         | 1.07  | 16130                     | 3.08E+08                    | 1.93E+06                         | 2.15E+06                         | 1                        | 1    | 2    | 3.79E+06                          | 5.73E+06 | 7.42E+06 | 5.05E+08                             | 7.63E+08 | 9.89E+08 |
| HE340A  | 330         | 300         | 1.10  | 13350                     | 2.77E+08                    | 1.68E+06                         | 1.85E+06                         | 1                        | 3    | 3    | 3.14E+06                          | 4.74E+06 | 6.14E+06 | 4.35E+08                             | 5.96E+08 | 7.72E+08 |
| HE340B  | 340         | 300         | 1.13  | 17090                     | 3.67E+08                    | 2.16E+06                         | 2.41E+06                         | 1                        | 1    | 1    | 4.02E+06                          | 6.07E+06 | 7.86E+06 | 5.66E+08                             | 8.55E+08 | 1.11E+09 |
| HE360A  | 350         | 300         | 1.17  | 14280                     | 3.31E+08                    | 1.89E+06                         | 2.09E+06                         | 1                        | 2    | 3    | 3.36E+06                          | 5.07E+06 | 6.57E+06 | 4.91E+08                             | 7.41E+08 | 8.70E+08 |
| HE360B  | 360         | 300         | 1.20  | 18060                     | 4.32E+08                    | 2.40E+06                         | 2.68E+06                         | 1                        | 1    | 1    | 4.24E+06                          | 6.41E+06 | 8.31E+06 | 6.31E+08                             | 9.52E+08 | 1.23E+09 |
| HE400A  | 390         | 300         | 1.30  | 15900                     | 4.51E+08                    | 2.31E+06                         | 2.56E+06                         | 1                        | 2    | 3    | 3.74E+06                          | 5.64E+06 | 7.31E+06 | 6.02E+08                             | 9.10E+08 | 1.06E+09 |
| HE400B  | 400         | 300         | 1.33  | 19780                     | 5.77E+08                    | 2.88E+06                         | 3.23E+06                         | 1                        | 1    | 1    | 4.65E+06                          | 7.02E+06 | 9.10E+06 | 7.60E+08                             | 1.15E+09 | 1.49E+09 |
| HE450A  | 440         | 300         | 1.47  | 17800                     | 6.37E+08                    | 2.90E+06                         | 3.22E+06                         | 1                        | 2    | 3    | 4.18E+06                          | 6.32E+06 | 8.19E+06 | 7.56E+08                             | 1.14E+09 | 1.33E+09 |
| HE450B  | 450         | 300         | 1.50  | 21800                     | 7.99E+08                    | 3.55E+06                         | 3.98E+06                         | 1                        | 1    | 2    | 5.12E+06                          | 7.74E+06 | 1.00E+07 | 9.36E+08                             | 1.41E+09 | 1.83E+09 |
| HE500A  | 490         | 300         | 1.63  | 19750                     | 8.70E+08                    | 3.55E+06                         | 3.95E+06                         | 1                        | 3    | 4    | 4.64E+06                          | 7.01E+06 |          | 9.28E+08                             | 1.26E+09 |          |
| HE500B  | 500         | 300         | 1.67  | 23860                     | 1.07E+09                    | 4.29E+06                         | 4.82E+06                         | 1                        | 2    | 2    | 5.61E+06                          | 8.47E+06 | 1.10E+07 | 1.13E+09                             | 1.71E+09 | 2.21E+09 |



Table A1.2: Column slenderness,  $L = 4$  m

| Section | Fixed-fixed column |      |      |            |      |      | Pinned-pinned column |      |      | Fixed-guided column |      |      |           |      |      | Pinned-guided column |      |      |
|---------|--------------------|------|------|------------|------|------|----------------------|------|------|---------------------|------|------|-----------|------|------|----------------------|------|------|
|         | $K = 0.5$          |      |      | $K = 0.65$ |      |      | $K = 1.0$            |      |      | $K = 1.0$           |      |      | $K = 1.2$ |      |      | $K = 2.0$            |      |      |
|         | S235               | S355 | S460 | S235       | S355 | S460 | S235                 | S355 | S460 | S235                | S355 | S460 | S235      | S355 | S460 | S235                 | S355 | S460 |
| HE100A  | 0.52               | 0.64 | 0.73 | 0.68       | 0.84 | 0.95 | 1.05                 | 1.29 | 1.47 | 1.05                | 1.29 | 1.47 | 1.26      | 1.55 | 1.76 | 2.10                 | 2.58 | 2.94 |
| HE100B  | 0.51               | 0.63 | 0.72 | 0.67       | 0.82 | 0.93 | 1.02                 | 1.26 | 1.43 | 1.02                | 1.26 | 1.43 | 1.23      | 1.51 | 1.72 | 2.05                 | 2.52 | 2.87 |
| HE120A  | 0.44               | 0.53 | 0.61 | 0.57       | 0.70 | 0.79 | 0.87                 | 1.07 | 1.22 | 0.87                | 1.07 | 1.22 | 1.04      | 1.28 | 1.46 | 1.74                 | 2.14 | 2.43 |
| HE120B  | 0.42               | 0.52 | 0.59 | 0.55       | 0.67 | 0.77 | 0.84                 | 1.04 | 1.18 | 0.84                | 1.04 | 1.18 | 1.01      | 1.25 | 1.42 | 1.69                 | 2.08 | 2.36 |
| HE140A  | 0.37               | 0.46 | 0.52 | 0.48       | 0.59 | 0.68 | 0.74                 | 0.91 | 1.04 | 0.74                | 0.91 | 1.04 | 0.89      | 1.10 | 1.25 | 1.49                 | 1.83 | 2.08 |
| HE140B  | 0.36               | 0.44 | 0.50 | 0.47       | 0.57 | 0.65 | 0.72                 | 0.88 | 1.01 | 0.72                | 0.88 | 1.01 | 0.86      | 1.06 | 1.21 | 1.44                 | 1.77 | 2.01 |
| HE160A  | 0.32               | 0.40 | 0.45 | 0.42       | 0.52 | 0.59 | 0.65                 | 0.80 | 0.91 | 0.65                | 0.80 | 0.91 | 0.78      | 0.96 | 1.09 | 1.30                 | 1.59 | 1.82 |
| HE160B  | 0.31               | 0.39 | 0.44 | 0.41       | 0.50 | 0.57 | 0.63                 | 0.77 | 0.88 | 0.63                | 0.77 | 0.88 | 0.75      | 0.93 | 1.06 | 1.26                 | 1.55 | 1.76 |
| HE180A  | 0.29               | 0.35 | 0.40 | 0.37       | 0.46 | 0.52 | 0.57                 | 0.70 | 0.80 | 0.57                | 0.70 | 0.80 | 0.69      | 0.84 | 0.96 | 1.14                 | 1.41 | 1.60 |
| HE180B  | 0.28               | 0.34 | 0.39 | 0.36       | 0.44 | 0.51 | 0.56                 | 0.68 | 0.78 | 0.56                | 0.68 | 0.78 | 0.67      | 0.82 | 0.93 | 1.11                 | 1.37 | 1.56 |
| HE200A  | 0.26               | 0.32 | 0.36 | 0.33       | 0.41 | 0.47 | 0.51                 | 0.63 | 0.72 | 0.51                | 0.63 | 0.72 | 0.62      | 0.76 | 0.86 | 1.03                 | 1.26 | 1.44 |
| HE200B  | 0.25               | 0.31 | 0.35 | 0.32       | 0.40 | 0.45 | 0.50                 | 0.61 | 0.70 | 0.50                | 0.61 | 0.70 | 0.60      | 0.74 | 0.84 | 1.00                 | 1.23 | 1.40 |
| HE220A  | 0.23               | 0.29 | 0.32 | 0.30       | 0.37 | 0.42 | 0.46                 | 0.57 | 0.65 | 0.46                | 0.57 | 0.65 | 0.56      | 0.68 | 0.78 | 0.93                 | 1.14 | 1.30 |
| HE220B  | 0.23               | 0.28 | 0.32 | 0.29       | 0.36 | 0.41 | 0.45                 | 0.56 | 0.63 | 0.45                | 0.56 | 0.63 | 0.54      | 0.67 | 0.76 | 0.90                 | 1.11 | 1.26 |
| HE240A  | 0.21               | 0.26 | 0.30 | 0.28       | 0.34 | 0.39 | 0.42                 | 0.52 | 0.59 | 0.42                | 0.52 | 0.59 | 0.51      | 0.62 | 0.71 | 0.85                 | 1.04 | 1.19 |
| HE240B  | 0.21               | 0.25 | 0.29 | 0.27       | 0.33 | 0.38 | 0.41                 | 0.51 | 0.58 | 0.41                | 0.51 | 0.58 | 0.50      | 0.61 | 0.69 | 0.83                 | 1.02 | 1.16 |
| HE260A  | 0.19               | 0.24 | 0.27 | 0.25       | 0.31 | 0.35 | 0.39                 | 0.48 | 0.54 | 0.39                | 0.48 | 0.54 | 0.47      | 0.57 | 0.65 | 0.78                 | 0.95 | 1.09 |
| HE260B  | 0.19               | 0.23 | 0.27 | 0.25       | 0.30 | 0.35 | 0.38                 | 0.47 | 0.53 | 0.38                | 0.47 | 0.53 | 0.46      | 0.56 | 0.64 | 0.76                 | 0.93 | 1.06 |
| HE280A  | 0.18               | 0.22 |      | 0.23       | 0.29 |      | 0.36                 | 0.44 |      | 0.36                | 0.44 |      | 0.43      | 0.53 |      | 0.72                 | 0.88 |      |
| HE280B  | 0.18               | 0.22 | 0.25 | 0.23       | 0.28 | 0.32 | 0.35                 | 0.43 | 0.49 | 0.35                | 0.43 | 0.49 | 0.42      | 0.52 | 0.59 | 0.70                 | 0.86 | 0.98 |
| HE300A  | 0.17               | 0.21 | 0.23 | 0.22       | 0.27 | 0.30 | 0.33                 | 0.41 | 0.47 | 0.33                | 0.41 | 0.47 | 0.40      | 0.49 | 0.56 | 0.67                 | 0.82 | 0.94 |
| HE300B  | 0.16               | 0.20 | 0.23 | 0.21       | 0.26 | 0.30 | 0.33                 | 0.40 | 0.46 | 0.33                | 0.40 | 0.46 | 0.39      | 0.48 | 0.55 | 0.66                 | 0.81 | 0.92 |
| HE320A  | 0.16               | 0.19 | 0.22 | 0.20       | 0.25 | 0.29 | 0.31                 | 0.39 | 0.44 | 0.31                | 0.39 | 0.44 | 0.38      | 0.46 | 0.53 | 0.63                 | 0.77 | 0.88 |
| HE320B  | 0.15               | 0.19 | 0.22 | 0.20       | 0.25 | 0.28 | 0.31                 | 0.38 | 0.43 | 0.31                | 0.38 | 0.43 | 0.37      | 0.45 | 0.52 | 0.62                 | 0.76 | 0.86 |
| HE340A  | 0.15               | 0.18 | 0.21 | 0.19       | 0.24 | 0.27 | 0.30                 | 0.36 | 0.41 | 0.30                | 0.36 | 0.41 | 0.35      | 0.44 | 0.50 | 0.59                 | 0.73 | 0.83 |
| HE340B  | 0.15               | 0.18 | 0.20 | 0.19       | 0.23 | 0.26 | 0.29                 | 0.36 | 0.41 | 0.29                | 0.36 | 0.41 | 0.35      | 0.43 | 0.49 | 0.58                 | 0.71 | 0.81 |
| HE360A  | 0.14               | 0.17 | 0.20 | 0.18       | 0.22 | 0.25 | 0.28                 | 0.34 | 0.39 | 0.28                | 0.34 | 0.39 | 0.34      | 0.41 | 0.47 | 0.56                 | 0.69 | 0.78 |
| HE360B  | 0.14               | 0.17 | 0.19 | 0.18       | 0.22 | 0.25 | 0.28                 | 0.34 | 0.39 | 0.28                | 0.34 | 0.39 | 0.33      | 0.41 | 0.46 | 0.55                 | 0.68 | 0.77 |
| HE400A  | 0.13               | 0.16 | 0.18 | 0.16       | 0.20 | 0.23 | 0.25                 | 0.31 | 0.35 | 0.25                | 0.31 | 0.35 | 0.30      | 0.37 | 0.42 | 0.51                 | 0.62 | 0.71 |
| HE400B  | 0.12               | 0.15 | 0.17 | 0.16       | 0.20 | 0.23 | 0.25                 | 0.31 | 0.35 | 0.25                | 0.31 | 0.35 | 0.30      | 0.37 | 0.42 | 0.50                 | 0.61 | 0.70 |
| HE450A  | 0.11               | 0.14 | 0.16 | 0.15       | 0.18 | 0.20 | 0.23                 | 0.28 | 0.31 | 0.23                | 0.28 | 0.31 | 0.27      | 0.33 | 0.38 | 0.45                 | 0.55 | 0.63 |
| HE450B  | 0.11               | 0.14 | 0.16 | 0.14       | 0.18 | 0.20 | 0.22                 | 0.27 | 0.31 | 0.22                | 0.27 | 0.31 | 0.27      | 0.33 | 0.37 | 0.44                 | 0.55 | 0.62 |
| HE500A  | 0.10               | 0.12 |      | 0.13       | 0.16 |      | 0.20                 | 0.25 |      | 0.20                | 0.25 |      | 0.24      | 0.30 |      | 0.41                 | 0.50 |      |
| HE500B  | 0.10               | 0.12 | 0.14 | 0.13       | 0.16 | 0.18 | 0.20                 | 0.25 | 0.28 | 0.20                | 0.25 | 0.28 | 0.24      | 0.30 | 0.34 | 0.40                 | 0.49 | 0.56 |

**Table A1.3:** Ratio  $M_{\text{splice}}/M_{\text{Rd}}$ ,  $L = 4 \text{ m}$ ,  $H_{\text{spl}} = 0.1L$

| Section | Fixed-fixed column |      |      |            |      |      | Pinned-pinned column |      |      | Fixed-guided column |      |      |           |      |      | Pinned-guided column |      |      |
|---------|--------------------|------|------|------------|------|------|----------------------|------|------|---------------------|------|------|-----------|------|------|----------------------|------|------|
|         | $K = 0.5$          |      |      | $K = 0.65$ |      |      | $K = 1.0$            |      |      | $K = 1.0$           |      |      | $K = 1.2$ |      |      | $K = 2.0$            |      |      |
|         | S235               | S355 | S460 | S235       | S355 | S460 | S235                 | S355 | S460 | S235                | S355 | S460 | S235      | S355 | S460 | S235                 | S355 | S460 |
| HE100A  | 0.10               | 0.15 | 0.14 | 0.17       | 0.24 | 0.24 | 0.13                 | 0.18 | 0.19 | 0.41                | 0.54 | 0.58 | 0.53      | 0.64 | 0.68 | 0.13                 | 0.14 | 0.14 |
| HE100B  | 0.10               | 0.14 | 0.13 | 0.16       | 0.23 | 0.23 | 0.13                 | 0.17 | 0.18 | 0.40                | 0.53 | 0.57 | 0.51      | 0.63 | 0.67 | 0.13                 | 0.13 | 0.14 |
| HE120A  | 0.07               | 0.11 | 0.09 | 0.12       | 0.17 | 0.16 | 0.10                 | 0.14 | 0.15 | 0.30                | 0.42 | 0.46 | 0.41      | 0.54 | 0.58 | 0.11                 | 0.13 | 0.13 |
| HE120B  | 0.07               | 0.10 | 0.09 | 0.11       | 0.16 | 0.15 | 0.09                 | 0.13 | 0.14 | 0.29                | 0.41 | 0.44 | 0.39      | 0.52 | 0.56 | 0.11                 | 0.13 | 0.13 |
| HE140A  | 0.05               | 0.08 | 0.07 | 0.09       | 0.13 | 0.11 | 0.07                 | 0.11 | 0.11 | 0.23                | 0.33 | 0.34 | 0.32      | 0.44 | 0.47 | 0.10                 | 0.12 | 0.12 |
| HE140B  | 0.05               | 0.07 | 0.06 | 0.08       | 0.12 | 0.11 | 0.07                 | 0.10 | 0.10 | 0.22                | 0.31 | 0.32 | 0.30      | 0.42 | 0.45 | 0.10                 | 0.12 | 0.12 |
| HE160A  | 0.04               | 0.06 | 0.05 | 0.07       | 0.10 | 0.09 | 0.06                 | 0.08 | 0.08 | 0.18                | 0.26 | 0.26 | 0.25      | 0.36 | 0.38 | 0.09                 | 0.11 | 0.11 |
| HE160B  | 0.03               | 0.06 | 0.05 | 0.06       | 0.09 | 0.08 | 0.05                 | 0.08 | 0.08 | 0.17                | 0.25 | 0.24 | 0.24      | 0.34 | 0.35 | 0.09                 | 0.11 | 0.11 |
| HE180A  | 0.02               | 0.04 | 0.04 | 0.05       | 0.08 | 0.07 | 0.05                 | 0.07 | 0.06 | 0.14                | 0.21 | 0.19 | 0.20      | 0.29 | 0.29 | 0.08                 | 0.10 | 0.10 |
| HE180B  | 0.02               | 0.04 | 0.04 | 0.05       | 0.07 | 0.06 | 0.04                 | 0.06 | 0.06 | 0.13                | 0.20 | 0.18 | 0.19      | 0.27 | 0.27 | 0.07                 | 0.09 | 0.10 |
| HE200A  | 0.02               | 0.03 | 0.03 | 0.04       | 0.06 | 0.05 | 0.04                 | 0.06 | 0.05 | 0.12                | 0.17 | 0.15 | 0.16      | 0.24 | 0.23 | 0.07                 | 0.09 | 0.09 |
| HE200B  | 0.01               | 0.03 | 0.03 | 0.04       | 0.06 | 0.05 | 0.04                 | 0.05 | 0.05 | 0.11                | 0.16 | 0.14 | 0.15      | 0.23 | 0.22 | 0.06                 | 0.08 | 0.09 |
| HE220A  | 0.01               | 0.02 | 0.02 | 0.03       | 0.05 | 0.04 | 0.03                 | 0.05 | 0.04 | 0.10                | 0.14 | 0.12 | 0.14      | 0.20 | 0.18 | 0.06                 | 0.08 | 0.08 |
| HE220B  | 0.01               | 0.02 | 0.02 | 0.03       | 0.05 | 0.04 | 0.03                 | 0.04 | 0.04 | 0.09                | 0.13 | 0.12 | 0.13      | 0.19 | 0.17 | 0.05                 | 0.07 | 0.08 |
| HE240A  | 0.00               | 0.02 | 0.02 | 0.02       | 0.04 | 0.04 | 0.03                 | 0.04 | 0.03 | 0.08                | 0.12 | 0.10 | 0.11      | 0.17 | 0.15 | 0.05                 | 0.07 | 0.07 |
| HE240B  | 0.00               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.02                 | 0.04 | 0.03 | 0.08                | 0.11 | 0.10 | 0.11      | 0.16 | 0.14 | 0.05                 | 0.06 | 0.07 |
| HE260A  | 0.00               | 0.01 | 0.01 | 0.02       | 0.03 | 0.03 | 0.02                 | 0.03 | 0.03 | 0.07                | 0.10 | 0.09 | 0.10      | 0.14 | 0.12 | 0.04                 | 0.06 | 0.06 |
| HE260B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.03 | 0.03 | 0.02                 | 0.03 | 0.03 | 0.06                | 0.10 | 0.08 | 0.09      | 0.14 | 0.12 | 0.04                 | 0.06 | 0.06 |
| HE280A  | 0.00               | 0.01 |      | 0.01       | 0.03 |      | 0.02                 | 0.03 |      | 0.06                | 0.09 |      | 0.08      | 0.12 |      | 0.04                 | 0.05 |      |
| HE280B  | 0.00               | 0.00 | 0.01 | 0.01       | 0.02 | 0.02 | 0.02                 | 0.03 | 0.02 | 0.05                | 0.08 | 0.07 | 0.08      | 0.12 | 0.10 | 0.03                 | 0.05 | 0.05 |
| HE300A  | 0.00               | 0.00 | 0.01 | 0.00       | 0.02 | 0.02 | 0.02                 | 0.02 | 0.02 | 0.05                | 0.07 | 0.06 | 0.07      | 0.11 | 0.09 | 0.03                 | 0.05 | 0.05 |
| HE300B  | 0.00               | 0.00 | 0.01 | 0.00       | 0.02 | 0.02 | 0.01                 | 0.02 | 0.02 | 0.04                | 0.07 | 0.06 | 0.07      | 0.10 | 0.09 | 0.03                 | 0.04 | 0.04 |
| HE320A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.02 | 0.01                 | 0.02 | 0.02 | 0.04                | 0.06 | 0.05 | 0.06      | 0.09 | 0.08 | 0.03                 | 0.04 | 0.04 |
| HE320B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.01                 | 0.02 | 0.02 | 0.04                | 0.06 | 0.05 | 0.06      | 0.09 | 0.08 | 0.03                 | 0.04 | 0.04 |
| HE340A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.01                 | 0.02 | 0.02 | 0.03                | 0.06 | 0.05 | 0.05      | 0.08 | 0.07 | 0.02                 | 0.04 | 0.03 |
| HE340B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.01                 | 0.02 | 0.02 | 0.03                | 0.05 | 0.05 | 0.05      | 0.08 | 0.07 | 0.02                 | 0.04 | 0.03 |
| HE360A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.01                 | 0.02 | 0.01 | 0.03                | 0.05 | 0.04 | 0.05      | 0.08 | 0.06 | 0.02                 | 0.03 | 0.03 |
| HE360B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.01                 | 0.02 | 0.01 | 0.03                | 0.05 | 0.04 | 0.04      | 0.07 | 0.06 | 0.02                 | 0.03 | 0.03 |
| HE400A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.00                 | 0.01 | 0.01 | 0.01                | 0.02 | 0.02 | 0.02      | 0.04 | 0.03 | 0.01                 | 0.02 | 0.02 |
| HE400B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.00                 | 0.01 | 0.01 | 0.01                | 0.02 | 0.02 | 0.02      | 0.04 | 0.03 | 0.01                 | 0.02 | 0.02 |
| HE450A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.00                 | 0.01 | 0.01 | 0.01                | 0.02 | 0.02 | 0.01      | 0.03 | 0.02 | 0.01                 | 0.01 | 0.01 |
| HE450B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.00                 | 0.01 | 0.00 | 0.00                | 0.02 | 0.01 | 0.01      | 0.03 | 0.02 | 0.01                 | 0.01 | 0.01 |
| HE500A  | 0.00               | 0.00 |      | 0.00       | 0.00 |      | 0.00                 | 0.00 |      | 0.00                | 0.01 |      | 0.01      | 0.02 |      | 0.01                 | 0.01 |      |
| HE500B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.00                 | 0.00 | 0.00 | 0.00                | 0.01 | 0.01 | 0.01      | 0.02 | 0.02 | 0.01                 | 0.01 | 0.01 |



Table A1.4: Ratio  $M_{\text{splice}}/M_{\text{Rd}}$ ,  $L = 4 \text{ m}$ ,  $H_{\text{spl}} = 0.2L$ 

| Section | Fixed-fixed column |      |      |            |      |      | Pinned-pinned column |      |      | Fixed-guided column |      |      |           |      |      | Pinned-guided column |      |      |
|---------|--------------------|------|------|------------|------|------|----------------------|------|------|---------------------|------|------|-----------|------|------|----------------------|------|------|
|         | $K = 0.5$          |      |      | $K = 0.65$ |      |      | $K = 1.0$            |      |      | $K = 1.0$           |      |      | $K = 1.2$ |      |      | $K = 2.0$            |      |      |
|         | S235               | S355 | S460 | S235       | S355 | S460 | S235                 | S355 | S460 | S235                | S355 | S460 | S235      | S355 | S460 | S235                 | S355 | S460 |
| HE100A  | 0.04               | 0.06 | 0.05 | 0.06       | 0.09 | 0.09 | 0.26                 | 0.33 | 0.36 | 0.35                | 0.46 | 0.50 | 0.45      | 0.55 | 0.58 | 0.25                 | 0.27 | 0.28 |
| HE100B  | 0.04               | 0.06 | 0.05 | 0.06       | 0.09 | 0.09 | 0.25                 | 0.32 | 0.35 | 0.34                | 0.45 | 0.48 | 0.43      | 0.54 | 0.57 | 0.25                 | 0.27 | 0.27 |
| HE120A  | 0.03               | 0.04 | 0.04 | 0.05       | 0.07 | 0.06 | 0.19                 | 0.26 | 0.28 | 0.26                | 0.36 | 0.39 | 0.35      | 0.46 | 0.49 | 0.23                 | 0.25 | 0.26 |
| HE120B  | 0.03               | 0.04 | 0.03 | 0.04       | 0.06 | 0.06 | 0.18                 | 0.25 | 0.27 | 0.25                | 0.35 | 0.37 | 0.33      | 0.44 | 0.48 | 0.22                 | 0.25 | 0.26 |
| HE140A  | 0.02               | 0.03 | 0.03 | 0.03       | 0.05 | 0.04 | 0.14                 | 0.20 | 0.21 | 0.19                | 0.28 | 0.29 | 0.27      | 0.37 | 0.40 | 0.20                 | 0.23 | 0.24 |
| HE140B  | 0.02               | 0.03 | 0.02 | 0.03       | 0.05 | 0.04 | 0.13                 | 0.19 | 0.20 | 0.18                | 0.27 | 0.27 | 0.25      | 0.36 | 0.38 | 0.20                 | 0.23 | 0.24 |
| HE160A  | 0.01               | 0.02 | 0.02 | 0.03       | 0.04 | 0.03 | 0.11                 | 0.16 | 0.16 | 0.15                | 0.22 | 0.22 | 0.21      | 0.30 | 0.32 | 0.18                 | 0.21 | 0.23 |
| HE160B  | 0.01               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.10                 | 0.15 | 0.15 | 0.14                | 0.21 | 0.20 | 0.20      | 0.29 | 0.30 | 0.17                 | 0.21 | 0.22 |
| HE180A  | 0.01               | 0.02 | 0.01 | 0.02       | 0.03 | 0.03 | 0.09                 | 0.13 | 0.12 | 0.12                | 0.18 | 0.17 | 0.17      | 0.25 | 0.25 | 0.15                 | 0.19 | 0.21 |
| HE180B  | 0.01               | 0.02 | 0.01 | 0.02       | 0.03 | 0.02 | 0.08                 | 0.12 | 0.11 | 0.11                | 0.17 | 0.16 | 0.16      | 0.23 | 0.23 | 0.15                 | 0.19 | 0.20 |
| HE200A  | 0.01               | 0.01 | 0.01 | 0.02       | 0.02 | 0.02 | 0.07                 | 0.11 | 0.09 | 0.10                | 0.15 | 0.13 | 0.14      | 0.20 | 0.20 | 0.13                 | 0.17 | 0.19 |
| HE200B  | 0.01               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.07                 | 0.10 | 0.09 | 0.09                | 0.14 | 0.12 | 0.13      | 0.19 | 0.18 | 0.12                 | 0.17 | 0.18 |
| HE220A  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.06                 | 0.09 | 0.08 | 0.08                | 0.12 | 0.11 | 0.11      | 0.17 | 0.16 | 0.11                 | 0.15 | 0.16 |
| HE220B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.06                 | 0.08 | 0.07 | 0.08                | 0.11 | 0.10 | 0.11      | 0.16 | 0.15 | 0.11                 | 0.15 | 0.16 |
| HE240A  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.01 | 0.05                 | 0.07 | 0.06 | 0.07                | 0.10 | 0.09 | 0.10      | 0.14 | 0.13 | 0.09                 | 0.13 | 0.14 |
| HE240B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.01 | 0.01 | 0.05                 | 0.07 | 0.06 | 0.06                | 0.10 | 0.08 | 0.09      | 0.14 | 0.12 | 0.09                 | 0.13 | 0.14 |
| HE260A  | 0.00               | 0.00 | 0.00 | 0.01       | 0.01 | 0.01 | 0.04                 | 0.06 | 0.05 | 0.06                | 0.09 | 0.07 | 0.08      | 0.12 | 0.11 | 0.08                 | 0.12 | 0.12 |
| HE260B  | 0.00               | 0.00 | 0.00 | 0.01       | 0.01 | 0.01 | 0.04                 | 0.06 | 0.05 | 0.05                | 0.08 | 0.07 | 0.08      | 0.12 | 0.10 | 0.08                 | 0.11 | 0.12 |
| HE280A  | 0.00               | 0.00 |      | 0.00       | 0.01 |      | 0.03                 | 0.05 |      | 0.05                | 0.07 |      | 0.07      | 0.10 |      | 0.07                 | 0.10 |      |
| HE280B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.05 | 0.04 | 0.04                | 0.07 | 0.06 | 0.07      | 0.10 | 0.09 | 0.07                 | 0.10 | 0.10 |
| HE300A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.05 | 0.04 | 0.04                | 0.06 | 0.05 | 0.06      | 0.09 | 0.08 | 0.06                 | 0.09 | 0.09 |
| HE300B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.04 | 0.04 | 0.04                | 0.06 | 0.05 | 0.06      | 0.09 | 0.07 | 0.06                 | 0.09 | 0.09 |
| HE320A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.02                 | 0.04 | 0.03 | 0.03                | 0.06 | 0.05 | 0.05      | 0.08 | 0.07 | 0.05                 | 0.08 | 0.08 |
| HE320B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.02                 | 0.04 | 0.03 | 0.03                | 0.05 | 0.04 | 0.05      | 0.08 | 0.07 | 0.05                 | 0.08 | 0.07 |
| HE340A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.02                 | 0.04 | 0.03 | 0.03                | 0.05 | 0.04 | 0.05      | 0.07 | 0.06 | 0.05                 | 0.07 | 0.07 |
| HE340B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.02                 | 0.03 | 0.03 | 0.03                | 0.05 | 0.04 | 0.04      | 0.07 | 0.06 | 0.05                 | 0.07 | 0.07 |
| HE360A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.02                 | 0.03 | 0.03 | 0.02                | 0.04 | 0.04 | 0.04      | 0.06 | 0.05 | 0.04                 | 0.06 | 0.06 |
| HE360B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.02                 | 0.03 | 0.03 | 0.02                | 0.04 | 0.04 | 0.04      | 0.06 | 0.05 | 0.04                 | 0.06 | 0.06 |
| HE400A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.01                 | 0.01 | 0.01 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.03 | 0.02                 | 0.04 | 0.03 |
| HE400B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.01                 | 0.01 | 0.01 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.03 | 0.02                 | 0.04 | 0.03 |
| HE450A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.00                 | 0.01 | 0.01 | 0.00                | 0.01 | 0.01 | 0.01      | 0.02 | 0.02 | 0.02                 | 0.03 | 0.02 |
| HE450B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.00                 | 0.01 | 0.01 | 0.00                | 0.01 | 0.01 | 0.01      | 0.02 | 0.02 | 0.02                 | 0.03 | 0.02 |
| HE500A  | 0.00               | 0.00 |      | 0.00       | 0.00 |      | 0.00                 | 0.01 |      | 0.00                | 0.01 |      | 0.01      | 0.02 |      | 0.02                 | 0.02 |      |
| HE500B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.00                 | 0.01 | 0.01 | 0.00                | 0.01 | 0.01 | 0.01      | 0.02 | 0.02 | 0.01                 | 0.02 | 0.02 |



**Table A1.5:** Ratio  $M_{\text{splice}}/M_{\text{Rd}}$ ,  $L = 4 \text{ m}$ ,  $H_{\text{spl}} = 0.4L$

| Section | Fixed-fixed column |      |      |            |      |      | Pinned-pinned column |      |      | Fixed-guided column |      |      |           |      |      | Pinned-guided column |      |      |
|---------|--------------------|------|------|------------|------|------|----------------------|------|------|---------------------|------|------|-----------|------|------|----------------------|------|------|
|         | $K = 0.5$          |      |      | $K = 0.65$ |      |      | $K = 1.0$            |      |      | $K = 1.0$           |      |      | $K = 1.2$ |      |      | $K = 2.0$            |      |      |
|         | S235               | S355 | S460 | S235       | S355 | S460 | S235                 | S355 | S460 | S235                | S355 | S460 | S235      | S355 | S460 | S235                 | S355 | S460 |
| HE100A  | 0.10               | 0.15 | 0.14 | 0.17       | 0.24 | 0.24 | 0.41                 | 0.54 | 0.58 | 0.13                | 0.18 | 0.19 | 0.17      | 0.21 | 0.22 | 0.47                 | 0.51 | 0.52 |
| HE100B  | 0.10               | 0.14 | 0.13 | 0.16       | 0.23 | 0.23 | 0.40                 | 0.53 | 0.57 | 0.13                | 0.17 | 0.18 | 0.17      | 0.20 | 0.22 | 0.47                 | 0.51 | 0.52 |
| HE120A  | 0.07               | 0.11 | 0.09 | 0.12       | 0.17 | 0.16 | 0.30                 | 0.42 | 0.46 | 0.10                | 0.14 | 0.15 | 0.13      | 0.17 | 0.19 | 0.43                 | 0.48 | 0.50 |
| HE120B  | 0.07               | 0.10 | 0.09 | 0.11       | 0.16 | 0.15 | 0.29                 | 0.41 | 0.44 | 0.09                | 0.13 | 0.14 | 0.13      | 0.17 | 0.18 | 0.42                 | 0.47 | 0.49 |
| HE140A  | 0.05               | 0.08 | 0.07 | 0.09       | 0.13 | 0.11 | 0.23                 | 0.33 | 0.34 | 0.07                | 0.11 | 0.11 | 0.10      | 0.14 | 0.15 | 0.38                 | 0.44 | 0.47 |
| HE140B  | 0.05               | 0.07 | 0.06 | 0.08       | 0.12 | 0.11 | 0.22                 | 0.31 | 0.32 | 0.07                | 0.10 | 0.10 | 0.10      | 0.14 | 0.15 | 0.37                 | 0.43 | 0.46 |
| HE160A  | 0.04               | 0.06 | 0.05 | 0.07       | 0.10 | 0.09 | 0.18                 | 0.26 | 0.26 | 0.06                | 0.08 | 0.08 | 0.08      | 0.12 | 0.12 | 0.34                 | 0.41 | 0.43 |
| HE160B  | 0.03               | 0.06 | 0.05 | 0.06       | 0.09 | 0.08 | 0.17                 | 0.25 | 0.24 | 0.05                | 0.08 | 0.08 | 0.08      | 0.11 | 0.12 | 0.32                 | 0.40 | 0.42 |
| HE180A  | 0.02               | 0.04 | 0.04 | 0.05       | 0.08 | 0.07 | 0.14                 | 0.21 | 0.19 | 0.05                | 0.07 | 0.06 | 0.06      | 0.09 | 0.09 | 0.29                 | 0.37 | 0.39 |
| HE180B  | 0.02               | 0.04 | 0.04 | 0.05       | 0.07 | 0.06 | 0.13                 | 0.20 | 0.18 | 0.04                | 0.06 | 0.06 | 0.06      | 0.09 | 0.09 | 0.28                 | 0.36 | 0.38 |
| HE200A  | 0.02               | 0.03 | 0.03 | 0.04       | 0.06 | 0.05 | 0.12                 | 0.17 | 0.15 | 0.04                | 0.06 | 0.05 | 0.05      | 0.08 | 0.07 | 0.25                 | 0.33 | 0.35 |
| HE200B  | 0.01               | 0.03 | 0.03 | 0.04       | 0.06 | 0.05 | 0.11                 | 0.16 | 0.14 | 0.04                | 0.05 | 0.05 | 0.05      | 0.07 | 0.07 | 0.24                 | 0.31 | 0.34 |
| HE220A  | 0.01               | 0.02 | 0.02 | 0.03       | 0.05 | 0.04 | 0.10                 | 0.14 | 0.12 | 0.03                | 0.05 | 0.04 | 0.04      | 0.06 | 0.06 | 0.21                 | 0.29 | 0.31 |
| HE220B  | 0.01               | 0.02 | 0.02 | 0.03       | 0.05 | 0.04 | 0.09                 | 0.13 | 0.12 | 0.03                | 0.04 | 0.04 | 0.04      | 0.06 | 0.06 | 0.20                 | 0.28 | 0.30 |
| HE240A  | 0.00               | 0.02 | 0.02 | 0.02       | 0.04 | 0.04 | 0.08                 | 0.12 | 0.10 | 0.03                | 0.04 | 0.03 | 0.04      | 0.05 | 0.05 | 0.18                 | 0.25 | 0.27 |
| HE240B  | 0.00               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.08                 | 0.11 | 0.10 | 0.02                | 0.04 | 0.03 | 0.04      | 0.05 | 0.05 | 0.17                 | 0.24 | 0.26 |
| HE260A  | 0.00               | 0.01 | 0.01 | 0.02       | 0.03 | 0.03 | 0.07                 | 0.10 | 0.09 | 0.02                | 0.03 | 0.03 | 0.03      | 0.05 | 0.04 | 0.15                 | 0.22 | 0.23 |
| HE260B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.03 | 0.03 | 0.06                 | 0.10 | 0.08 | 0.02                | 0.03 | 0.03 | 0.03      | 0.04 | 0.04 | 0.15                 | 0.21 | 0.22 |
| HE280A  | 0.00               | 0.01 |      | 0.01       | 0.03 |      | 0.06                 | 0.09 |      | 0.02                | 0.03 |      | 0.03      | 0.04 |      | 0.13                 | 0.19 |      |
| HE280B  | 0.00               | 0.00 | 0.01 | 0.01       | 0.02 | 0.02 | 0.05                 | 0.08 | 0.07 | 0.02                | 0.03 | 0.02 | 0.03      | 0.04 | 0.03 | 0.13                 | 0.19 | 0.19 |
| HE300A  | 0.00               | 0.00 | 0.01 | 0.00       | 0.02 | 0.02 | 0.05                 | 0.07 | 0.06 | 0.02                | 0.02 | 0.02 | 0.02      | 0.03 | 0.03 | 0.12                 | 0.17 | 0.17 |
| HE300B  | 0.00               | 0.00 | 0.01 | 0.00       | 0.02 | 0.02 | 0.04                 | 0.07 | 0.06 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.03 | 0.11                 | 0.16 | 0.16 |
| HE320A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.02 | 0.04                 | 0.06 | 0.05 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.03 | 0.10                 | 0.15 | 0.15 |
| HE320B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.04                 | 0.06 | 0.05 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.03 | 0.10                 | 0.15 | 0.14 |
| HE340A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.06 | 0.05 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.02 | 0.09                 | 0.14 | 0.13 |
| HE340B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.05 | 0.05 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.02 | 0.09                 | 0.13 | 0.12 |
| HE360A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.05 | 0.04 | 0.01                | 0.02 | 0.01 | 0.02      | 0.02 | 0.02 | 0.08                 | 0.12 | 0.11 |
| HE360B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.05 | 0.04 | 0.01                | 0.02 | 0.01 | 0.01      | 0.02 | 0.02 | 0.08                 | 0.12 | 0.11 |
| HE400A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.01                 | 0.02 | 0.02 | 0.00                | 0.01 | 0.01 | 0.01      | 0.01 | 0.01 | 0.05                 | 0.07 | 0.06 |
| HE400B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.01                 | 0.02 | 0.02 | 0.00                | 0.01 | 0.01 | 0.01      | 0.01 | 0.01 | 0.04                 | 0.07 | 0.06 |
| HE450A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.01                 | 0.02 | 0.02 | 0.00                | 0.01 | 0.01 | 0.00      | 0.01 | 0.01 | 0.04                 | 0.05 | 0.05 |
| HE450B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.00                 | 0.02 | 0.01 | 0.00                | 0.01 | 0.00 | 0.00      | 0.01 | 0.01 | 0.03                 | 0.05 | 0.05 |
| HE500A  | 0.00               | 0.00 |      | 0.00       | 0.00 |      | 0.00                 | 0.01 |      | 0.00                | 0.00 |      | 0.00      | 0.01 |      | 0.03                 | 0.04 |      |
| HE500B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.00                 | 0.01 | 0.01 | 0.00                | 0.00 | 0.00 | 0.00      | 0.01 | 0.01 | 0.03                 | 0.04 | 0.04 |

Table A1.6: Ratio  $M_{\text{splice}}/M_{\text{Rd}}$ ,  $L = 4 \text{ m}$ ,  $H_{\text{spl}} = 0.6L$ 

| Section | Fixed-fixed column |      |      |            |      |      | Pinned-pinned column |      |      | Fixed-guided column |      |      |           |      |      | Pinned-guided column |      |      |
|---------|--------------------|------|------|------------|------|------|----------------------|------|------|---------------------|------|------|-----------|------|------|----------------------|------|------|
|         | $K = 0.5$          |      |      | $K = 0.65$ |      |      | $K = 1.0$            |      |      | $K = 1.0$           |      |      | $K = 1.2$ |      |      | $K = 2.0$            |      |      |
|         | S235               | S355 | S460 | S235       | S355 | S460 | S235                 | S355 | S460 | S235                | S355 | S460 | S235      | S355 | S460 | S235                 | S355 | S460 |
| HE100A  | 0.10               | 0.15 | 0.14 | 0.17       | 0.24 | 0.24 | 0.41                 | 0.54 | 0.58 | 0.13                | 0.18 | 0.19 | 0.17      | 0.21 | 0.22 | 0.65                 | 0.70 | 0.72 |
| HE100B  | 0.10               | 0.14 | 0.13 | 0.16       | 0.23 | 0.23 | 0.40                 | 0.53 | 0.57 | 0.13                | 0.17 | 0.18 | 0.17      | 0.20 | 0.22 | 0.65                 | 0.70 | 0.72 |
| HE120A  | 0.07               | 0.11 | 0.09 | 0.12       | 0.17 | 0.16 | 0.30                 | 0.42 | 0.46 | 0.10                | 0.14 | 0.15 | 0.13      | 0.17 | 0.19 | 0.59                 | 0.66 | 0.68 |
| HE120B  | 0.07               | 0.10 | 0.09 | 0.11       | 0.16 | 0.15 | 0.29                 | 0.41 | 0.44 | 0.09                | 0.13 | 0.14 | 0.13      | 0.17 | 0.18 | 0.58                 | 0.65 | 0.68 |
| HE140A  | 0.05               | 0.08 | 0.07 | 0.09       | 0.13 | 0.11 | 0.23                 | 0.33 | 0.34 | 0.07                | 0.11 | 0.11 | 0.10      | 0.14 | 0.15 | 0.53                 | 0.61 | 0.64 |
| HE140B  | 0.05               | 0.07 | 0.06 | 0.08       | 0.12 | 0.11 | 0.22                 | 0.31 | 0.32 | 0.07                | 0.10 | 0.10 | 0.10      | 0.14 | 0.15 | 0.51                 | 0.60 | 0.63 |
| HE160A  | 0.04               | 0.06 | 0.05 | 0.07       | 0.10 | 0.09 | 0.18                 | 0.26 | 0.26 | 0.06                | 0.08 | 0.08 | 0.08      | 0.12 | 0.12 | 0.46                 | 0.56 | 0.59 |
| HE160B  | 0.03               | 0.06 | 0.05 | 0.06       | 0.09 | 0.08 | 0.17                 | 0.25 | 0.24 | 0.05                | 0.08 | 0.08 | 0.08      | 0.11 | 0.12 | 0.45                 | 0.55 | 0.58 |
| HE180A  | 0.02               | 0.04 | 0.04 | 0.05       | 0.08 | 0.07 | 0.14                 | 0.21 | 0.19 | 0.05                | 0.07 | 0.06 | 0.06      | 0.09 | 0.09 | 0.40                 | 0.50 | 0.54 |
| HE180B  | 0.02               | 0.04 | 0.04 | 0.05       | 0.07 | 0.06 | 0.13                 | 0.20 | 0.18 | 0.04                | 0.06 | 0.06 | 0.06      | 0.09 | 0.09 | 0.38                 | 0.49 | 0.53 |
| HE200A  | 0.02               | 0.03 | 0.03 | 0.04       | 0.06 | 0.05 | 0.12                 | 0.17 | 0.15 | 0.04                | 0.06 | 0.05 | 0.05      | 0.08 | 0.07 | 0.34                 | 0.45 | 0.49 |
| HE200B  | 0.01               | 0.03 | 0.03 | 0.04       | 0.06 | 0.05 | 0.11                 | 0.16 | 0.14 | 0.04                | 0.05 | 0.05 | 0.05      | 0.07 | 0.07 | 0.32                 | 0.43 | 0.47 |
| HE220A  | 0.01               | 0.02 | 0.02 | 0.03       | 0.05 | 0.04 | 0.10                 | 0.14 | 0.12 | 0.03                | 0.05 | 0.04 | 0.04      | 0.06 | 0.06 | 0.29                 | 0.40 | 0.43 |
| HE220B  | 0.01               | 0.02 | 0.02 | 0.03       | 0.05 | 0.04 | 0.09                 | 0.13 | 0.12 | 0.03                | 0.04 | 0.04 | 0.04      | 0.06 | 0.06 | 0.28                 | 0.38 | 0.41 |
| HE240A  | 0.00               | 0.02 | 0.02 | 0.02       | 0.04 | 0.04 | 0.08                 | 0.12 | 0.10 | 0.03                | 0.04 | 0.03 | 0.04      | 0.05 | 0.05 | 0.25                 | 0.35 | 0.37 |
| HE240B  | 0.00               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.08                 | 0.11 | 0.10 | 0.02                | 0.04 | 0.03 | 0.04      | 0.05 | 0.05 | 0.24                 | 0.33 | 0.36 |
| HE260A  | 0.00               | 0.01 | 0.01 | 0.02       | 0.03 | 0.03 | 0.07                 | 0.10 | 0.09 | 0.02                | 0.03 | 0.03 | 0.03      | 0.05 | 0.04 | 0.21                 | 0.30 | 0.32 |
| HE260B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.03 | 0.03 | 0.06                 | 0.10 | 0.08 | 0.02                | 0.03 | 0.03 | 0.03      | 0.04 | 0.04 | 0.20                 | 0.29 | 0.31 |
| HE280A  | 0.00               | 0.01 |      | 0.01       | 0.03 |      | 0.06                 | 0.09 |      | 0.02                | 0.03 |      | 0.03      | 0.04 |      | 0.18                 | 0.27 |      |
| HE280B  | 0.00               | 0.00 | 0.01 | 0.01       | 0.02 | 0.02 | 0.05                 | 0.08 | 0.07 | 0.02                | 0.03 | 0.02 | 0.03      | 0.04 | 0.03 | 0.18                 | 0.26 | 0.26 |
| HE300A  | 0.00               | 0.00 | 0.01 | 0.00       | 0.02 | 0.02 | 0.05                 | 0.07 | 0.06 | 0.02                | 0.02 | 0.02 | 0.02      | 0.03 | 0.03 | 0.16                 | 0.23 | 0.23 |
| HE300B  | 0.00               | 0.00 | 0.01 | 0.00       | 0.02 | 0.02 | 0.04                 | 0.07 | 0.06 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.03 | 0.16                 | 0.23 | 0.22 |
| HE320A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.02 | 0.04                 | 0.06 | 0.05 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.03 | 0.14                 | 0.21 | 0.20 |
| HE320B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.04                 | 0.06 | 0.05 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.03 | 0.14                 | 0.20 | 0.20 |
| HE340A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.06 | 0.05 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.02 | 0.13                 | 0.19 | 0.18 |
| HE340B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.05 | 0.05 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.02 | 0.12                 | 0.18 | 0.17 |
| HE360A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.05 | 0.04 | 0.01                | 0.02 | 0.01 | 0.02      | 0.02 | 0.02 | 0.12                 | 0.17 | 0.16 |
| HE360B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.05 | 0.04 | 0.01                | 0.02 | 0.01 | 0.01      | 0.02 | 0.02 | 0.11                 | 0.16 | 0.15 |
| HE400A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.01                 | 0.02 | 0.02 | 0.00                | 0.01 | 0.01 | 0.01      | 0.01 | 0.01 | 0.06                 | 0.10 | 0.09 |
| HE400B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.01                 | 0.02 | 0.02 | 0.00                | 0.01 | 0.01 | 0.01      | 0.01 | 0.01 | 0.06                 | 0.09 | 0.08 |
| HE450A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.01                 | 0.02 | 0.02 | 0.00                | 0.01 | 0.01 | 0.00      | 0.01 | 0.01 | 0.05                 | 0.08 | 0.07 |
| HE450B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.00                 | 0.02 | 0.01 | 0.00                | 0.01 | 0.00 | 0.00      | 0.01 | 0.01 | 0.05                 | 0.07 | 0.06 |
| HE500A  | 0.00               | 0.00 |      | 0.00       | 0.00 |      | 0.00                 | 0.01 |      | 0.00                | 0.00 |      | 0.00      | 0.01 |      | 0.04                 | 0.06 |      |
| HE500B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.00                 | 0.01 | 0.01 | 0.00                | 0.00 | 0.00 | 0.00      | 0.01 | 0.01 | 0.04                 | 0.06 | 0.05 |



**Table A1.7:** Ratio  $M_{\text{splice}}/M_{\text{Rd}}$ ,  $L = 4 \text{ m}$ ,  $H_{\text{spl}} = 0.8L$

| Section | Fixed-fixed column |      |      |            |      |      | Pinned-pinned column |      |      | Fixed-guided column |      |      |           |      |      | Pinned-guided column |      |      |
|---------|--------------------|------|------|------------|------|------|----------------------|------|------|---------------------|------|------|-----------|------|------|----------------------|------|------|
|         | $K = 0.5$          |      |      | $K = 0.65$ |      |      | $K = 1.0$            |      |      | $K = 1.0$           |      |      | $K = 1.2$ |      |      | $K = 2.0$            |      |      |
|         | S235               | S355 | S460 | S235       | S355 | S460 | S235                 | S355 | S460 | S235                | S355 | S460 | S235      | S355 | S460 | S235                 | S355 | S460 |
| HE100A  | 0.04               | 0.06 | 0.05 | 0.06       | 0.09 | 0.09 | 0.26                 | 0.33 | 0.36 | 0.35                | 0.46 | 0.50 | 0.45      | 0.55 | 0.58 | 0.77                 | 0.83 | 0.85 |
| HE100B  | 0.04               | 0.06 | 0.05 | 0.06       | 0.09 | 0.09 | 0.25                 | 0.32 | 0.35 | 0.34                | 0.45 | 0.48 | 0.43      | 0.54 | 0.57 | 0.76                 | 0.82 | 0.84 |
| HE120A  | 0.03               | 0.04 | 0.04 | 0.05       | 0.07 | 0.06 | 0.19                 | 0.26 | 0.28 | 0.26                | 0.36 | 0.39 | 0.35      | 0.46 | 0.49 | 0.70                 | 0.77 | 0.80 |
| HE120B  | 0.03               | 0.04 | 0.03 | 0.04       | 0.06 | 0.06 | 0.18                 | 0.25 | 0.27 | 0.25                | 0.35 | 0.37 | 0.33      | 0.44 | 0.48 | 0.68                 | 0.76 | 0.80 |
| HE140A  | 0.02               | 0.03 | 0.03 | 0.03       | 0.05 | 0.04 | 0.14                 | 0.20 | 0.21 | 0.19                | 0.28 | 0.29 | 0.27      | 0.37 | 0.40 | 0.62                 | 0.72 | 0.75 |
| HE140B  | 0.02               | 0.03 | 0.02 | 0.03       | 0.05 | 0.04 | 0.13                 | 0.19 | 0.20 | 0.18                | 0.27 | 0.27 | 0.25      | 0.36 | 0.38 | 0.60                 | 0.70 | 0.74 |
| HE160A  | 0.01               | 0.02 | 0.02 | 0.03       | 0.04 | 0.03 | 0.11                 | 0.16 | 0.16 | 0.15                | 0.22 | 0.22 | 0.21      | 0.30 | 0.32 | 0.54                 | 0.66 | 0.70 |
| HE160B  | 0.01               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.10                 | 0.15 | 0.15 | 0.14                | 0.21 | 0.20 | 0.20      | 0.29 | 0.30 | 0.53                 | 0.64 | 0.68 |
| HE180A  | 0.01               | 0.02 | 0.01 | 0.02       | 0.03 | 0.03 | 0.09                 | 0.13 | 0.12 | 0.12                | 0.18 | 0.17 | 0.17      | 0.25 | 0.25 | 0.47                 | 0.59 | 0.63 |
| HE180B  | 0.01               | 0.02 | 0.01 | 0.02       | 0.03 | 0.02 | 0.08                 | 0.12 | 0.11 | 0.11                | 0.17 | 0.16 | 0.16      | 0.23 | 0.23 | 0.45                 | 0.57 | 0.62 |
| HE200A  | 0.01               | 0.01 | 0.01 | 0.02       | 0.02 | 0.02 | 0.07                 | 0.11 | 0.09 | 0.10                | 0.15 | 0.13 | 0.14      | 0.20 | 0.20 | 0.40                 | 0.53 | 0.57 |
| HE200B  | 0.01               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.07                 | 0.10 | 0.09 | 0.09                | 0.14 | 0.12 | 0.13      | 0.19 | 0.18 | 0.38                 | 0.51 | 0.55 |
| HE220A  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.06                 | 0.09 | 0.08 | 0.08                | 0.12 | 0.11 | 0.11      | 0.17 | 0.16 | 0.34                 | 0.47 | 0.50 |
| HE220B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.06                 | 0.08 | 0.07 | 0.08                | 0.11 | 0.10 | 0.11      | 0.16 | 0.15 | 0.32                 | 0.45 | 0.48 |
| HE240A  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.01 | 0.05                 | 0.07 | 0.06 | 0.07                | 0.10 | 0.09 | 0.10      | 0.14 | 0.13 | 0.29                 | 0.41 | 0.44 |
| HE240B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.01 | 0.01 | 0.05                 | 0.07 | 0.06 | 0.06                | 0.10 | 0.08 | 0.09      | 0.14 | 0.12 | 0.28                 | 0.39 | 0.42 |
| HE260A  | 0.00               | 0.00 | 0.00 | 0.01       | 0.01 | 0.01 | 0.04                 | 0.06 | 0.05 | 0.06                | 0.09 | 0.07 | 0.08      | 0.12 | 0.11 | 0.25                 | 0.36 | 0.38 |
| HE260B  | 0.00               | 0.00 | 0.00 | 0.01       | 0.01 | 0.01 | 0.04                 | 0.06 | 0.05 | 0.05                | 0.08 | 0.07 | 0.08      | 0.12 | 0.10 | 0.24                 | 0.34 | 0.36 |
| HE280A  | 0.00               | 0.00 |      | 0.00       | 0.01 |      | 0.03                 | 0.05 |      | 0.05                | 0.07 |      | 0.07      | 0.10 |      | 0.22                 | 0.31 |      |
| HE280B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.05 | 0.04 | 0.04                | 0.07 | 0.06 | 0.07      | 0.10 | 0.09 | 0.21                 | 0.30 | 0.31 |
| HE300A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.05 | 0.04 | 0.04                | 0.06 | 0.05 | 0.06      | 0.09 | 0.08 | 0.19                 | 0.27 | 0.28 |
| HE300B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.04 | 0.04 | 0.04                | 0.06 | 0.05 | 0.06      | 0.09 | 0.07 | 0.18                 | 0.27 | 0.26 |
| HE320A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.02                 | 0.04 | 0.03 | 0.03                | 0.06 | 0.05 | 0.05      | 0.08 | 0.07 | 0.17                 | 0.25 | 0.24 |
| HE320B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.02                 | 0.04 | 0.03 | 0.03                | 0.05 | 0.04 | 0.05      | 0.08 | 0.07 | 0.16                 | 0.24 | 0.23 |
| HE340A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.02                 | 0.04 | 0.03 | 0.03                | 0.05 | 0.04 | 0.05      | 0.07 | 0.06 | 0.15                 | 0.22 | 0.21 |
| HE340B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.02                 | 0.03 | 0.03 | 0.03                | 0.05 | 0.04 | 0.04      | 0.07 | 0.06 | 0.15                 | 0.21 | 0.20 |
| HE360A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.02                 | 0.03 | 0.03 | 0.02                | 0.04 | 0.04 | 0.04      | 0.06 | 0.05 | 0.14                 | 0.20 | 0.19 |
| HE360B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.02                 | 0.03 | 0.03 | 0.02                | 0.04 | 0.04 | 0.04      | 0.06 | 0.05 | 0.13                 | 0.19 | 0.18 |
| HE400A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.01                 | 0.01 | 0.01 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.03 | 0.07                 | 0.11 | 0.10 |
| HE400B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.01                 | 0.01 | 0.01 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.03 | 0.07                 | 0.11 | 0.10 |
| HE450A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.00                 | 0.01 | 0.01 | 0.00                | 0.01 | 0.01 | 0.01      | 0.02 | 0.02 | 0.06                 | 0.09 | 0.08 |
| HE450B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.00                 | 0.01 | 0.01 | 0.00                | 0.01 | 0.01 | 0.01      | 0.02 | 0.02 | 0.06                 | 0.09 | 0.07 |
| HE500A  | 0.00               | 0.00 |      | 0.00       | 0.00 |      | 0.00                 | 0.01 |      | 0.00                | 0.01 |      | 0.01      | 0.02 |      | 0.05                 | 0.07 |      |
| HE500B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.00                 | 0.01 | 0.01 | 0.00                | 0.01 | 0.01 | 0.01      | 0.02 | 0.02 | 0.05                 | 0.07 | 0.06 |

Table A1.8: Column slenderness,  $L = 6$  m

| Section | Fixed-fixed column |      |      |            |      |      | Pinned-pinned column |      |      | Fixed-guided column |      |      |           |      |      | Pinned-guided column |      |      |
|---------|--------------------|------|------|------------|------|------|----------------------|------|------|---------------------|------|------|-----------|------|------|----------------------|------|------|
|         | $K = 0.5$          |      |      | $K = 0.65$ |      |      | $K = 1.0$            |      |      | $K = 1.0$           |      |      | $K = 1.2$ |      |      | $K = 2.0$            |      |      |
|         | S235               | S355 | S460 | S235       | S355 | S460 | S235                 | S355 | S460 | S235                | S355 | S460 | S235      | S355 | S460 | S235                 | S355 | S460 |
| HE100A  | 0.79               | 0.97 | 1.10 | 1.02       | 1.26 | 1.43 | 1.57                 | 1.93 | 2.20 | 1.57                | 1.93 | 2.20 | 1.89      | 2.32 | 2.64 | 3.15                 | 3.87 | 4.40 |
| HE100B  | 0.77               | 0.94 | 1.07 | 1.00       | 1.23 | 1.40 | 1.54                 | 1.89 | 2.15 | 1.54                | 1.89 | 2.15 | 1.84      | 2.27 | 2.58 | 3.07                 | 3.78 | 4.30 |
| HE120A  | 0.65               | 0.80 | 0.91 | 0.85       | 1.04 | 1.19 | 1.31                 | 1.60 | 1.83 | 1.31                | 1.60 | 1.83 | 1.57      | 1.93 | 2.19 | 2.61                 | 3.21 | 3.65 |
| HE120B  | 0.63               | 0.78 | 0.89 | 0.82       | 1.01 | 1.15 | 1.27                 | 1.56 | 1.77 | 1.27                | 1.56 | 1.77 | 1.52      | 1.87 | 2.13 | 2.53                 | 3.11 | 3.55 |
| HE140A  | 0.56               | 0.68 | 0.78 | 0.72       | 0.89 | 1.01 | 1.11                 | 1.37 | 1.56 | 1.11                | 1.37 | 1.56 | 1.34      | 1.64 | 1.87 | 2.23                 | 2.74 | 3.12 |
| HE140B  | 0.54               | 0.66 | 0.75 | 0.70       | 0.86 | 0.98 | 1.08                 | 1.33 | 1.51 | 1.08                | 1.33 | 1.51 | 1.29      | 1.59 | 1.81 | 2.16                 | 2.65 | 3.02 |
| HE160A  | 0.49               | 0.60 | 0.68 | 0.63       | 0.78 | 0.88 | 0.97                 | 1.20 | 1.36 | 0.97                | 1.20 | 1.36 | 1.17      | 1.44 | 1.63 | 1.95                 | 2.39 | 2.72 |
| HE160B  | 0.47               | 0.58 | 0.66 | 0.61       | 0.75 | 0.86 | 0.94                 | 1.16 | 1.32 | 0.94                | 1.16 | 1.32 | 1.13      | 1.39 | 1.58 | 1.89                 | 2.32 | 2.64 |
| HE180A  | 0.43               | 0.53 | 0.60 | 0.56       | 0.69 | 0.78 | 0.86                 | 1.05 | 1.20 | 0.86                | 1.05 | 1.20 | 1.03      | 1.27 | 1.44 | 1.72                 | 2.11 | 2.40 |
| HE180B  | 0.42               | 0.51 | 0.58 | 0.54       | 0.67 | 0.76 | 0.83                 | 1.03 | 1.17 | 0.83                | 1.03 | 1.17 | 1.00      | 1.23 | 1.40 | 1.67                 | 2.05 | 2.33 |
| HE200A  | 0.39               | 0.47 | 0.54 | 0.50       | 0.62 | 0.70 | 0.77                 | 0.95 | 1.08 | 0.77                | 0.95 | 1.08 | 0.93      | 1.14 | 1.29 | 1.54                 | 1.90 | 2.16 |
| HE200B  | 0.37               | 0.46 | 0.52 | 0.49       | 0.60 | 0.68 | 0.75                 | 0.92 | 1.05 | 0.75                | 0.92 | 1.05 | 0.90      | 1.10 | 1.26 | 1.50                 | 1.84 | 2.09 |
| HE220A  | 0.35               | 0.43 | 0.49 | 0.45       | 0.56 | 0.63 | 0.70                 | 0.86 | 0.97 | 0.70                | 0.86 | 0.97 | 0.84      | 1.03 | 1.17 | 1.39                 | 1.71 | 1.95 |
| HE220B  | 0.34               | 0.42 | 0.47 | 0.44       | 0.54 | 0.62 | 0.68                 | 0.83 | 0.95 | 0.68                | 0.83 | 0.95 | 0.81      | 1.00 | 1.14 | 1.36                 | 1.67 | 1.90 |
| HE240A  | 0.32               | 0.39 | 0.44 | 0.41       | 0.51 | 0.58 | 0.64                 | 0.78 | 0.89 | 0.64                | 0.78 | 0.89 | 0.76      | 0.94 | 1.07 | 1.27                 | 1.56 | 1.78 |
| HE240B  | 0.31               | 0.38 | 0.43 | 0.40       | 0.50 | 0.56 | 0.62                 | 0.76 | 0.87 | 0.62                | 0.76 | 0.87 | 0.74      | 0.91 | 1.04 | 1.24                 | 1.52 | 1.73 |
| HE260A  | 0.29               | 0.36 | 0.41 | 0.38       | 0.47 | 0.53 | 0.58                 | 0.72 | 0.81 | 0.58                | 0.72 | 0.81 | 0.70      | 0.86 | 0.98 | 1.16                 | 1.43 | 1.63 |
| HE260B  | 0.28               | 0.35 | 0.40 | 0.37       | 0.45 | 0.52 | 0.57                 | 0.70 | 0.80 | 0.57                | 0.70 | 0.80 | 0.68      | 0.84 | 0.96 | 1.14                 | 1.40 | 1.59 |
| HE280A  | 0.27               | 0.33 |      | 0.35       | 0.43 |      | 0.54                 | 0.66 |      | 0.54                | 0.66 |      | 0.65      | 0.79 |      | 1.08                 | 1.32 |      |
| HE280B  | 0.26               | 0.32 | 0.37 | 0.34       | 0.42 | 0.48 | 0.53                 | 0.65 | 0.74 | 0.53                | 0.65 | 0.74 | 0.63      | 0.78 | 0.89 | 1.06                 | 1.30 | 1.48 |
| HE300A  | 0.25               | 0.31 | 0.35 | 0.33       | 0.40 | 0.46 | 0.50                 | 0.62 | 0.70 | 0.50                | 0.62 | 0.70 | 0.60      | 0.74 | 0.84 | 1.00                 | 1.23 | 1.40 |
| HE300B  | 0.25               | 0.30 | 0.34 | 0.32       | 0.39 | 0.45 | 0.49                 | 0.60 | 0.69 | 0.49                | 0.60 | 0.69 | 0.59      | 0.73 | 0.83 | 0.98                 | 1.21 | 1.38 |
| HE320A  | 0.24               | 0.29 | 0.33 | 0.31       | 0.38 | 0.43 | 0.47                 | 0.58 | 0.66 | 0.47                | 0.58 | 0.66 | 0.56      | 0.69 | 0.79 | 0.94                 | 1.16 | 1.32 |
| HE320B  | 0.23               | 0.28 | 0.32 | 0.30       | 0.37 | 0.42 | 0.46                 | 0.57 | 0.65 | 0.46                | 0.57 | 0.65 | 0.55      | 0.68 | 0.78 | 0.92                 | 1.14 | 1.29 |
| HE340A  | 0.22               | 0.27 | 0.31 | 0.29       | 0.35 | 0.40 | 0.44                 | 0.55 | 0.62 | 0.44                | 0.55 | 0.62 | 0.53      | 0.65 | 0.74 | 0.89                 | 1.09 | 1.24 |
| HE340B  | 0.22               | 0.27 | 0.31 | 0.28       | 0.35 | 0.40 | 0.44                 | 0.54 | 0.61 | 0.44                | 0.54 | 0.61 | 0.52      | 0.64 | 0.73 | 0.87                 | 1.07 | 1.22 |
| HE360A  | 0.21               | 0.26 | 0.29 | 0.27       | 0.34 | 0.38 | 0.42                 | 0.52 | 0.59 | 0.42                | 0.52 | 0.59 | 0.50      | 0.62 | 0.70 | 0.84                 | 1.03 | 1.17 |
| HE360B  | 0.21               | 0.25 | 0.29 | 0.27       | 0.33 | 0.38 | 0.41                 | 0.51 | 0.58 | 0.41                | 0.51 | 0.58 | 0.50      | 0.61 | 0.69 | 0.83                 | 1.02 | 1.16 |
| HE400A  | 0.19               | 0.23 | 0.27 | 0.25       | 0.30 | 0.35 | 0.38                 | 0.47 | 0.53 | 0.38                | 0.47 | 0.53 | 0.46      | 0.56 | 0.64 | 0.76                 | 0.93 | 1.06 |
| HE400B  | 0.19               | 0.23 | 0.26 | 0.24       | 0.30 | 0.34 | 0.37                 | 0.46 | 0.52 | 0.37                | 0.46 | 0.52 | 0.45      | 0.55 | 0.63 | 0.75                 | 0.92 | 1.05 |
| HE450A  | 0.17               | 0.21 | 0.24 | 0.22       | 0.27 | 0.31 | 0.34                 | 0.42 | 0.47 | 0.34                | 0.42 | 0.47 | 0.41      | 0.50 | 0.57 | 0.68                 | 0.83 | 0.94 |
| HE450B  | 0.17               | 0.21 | 0.23 | 0.22       | 0.27 | 0.30 | 0.33                 | 0.41 | 0.47 | 0.33                | 0.41 | 0.47 | 0.40      | 0.49 | 0.56 | 0.67                 | 0.82 | 0.93 |
| HE500A  | 0.15               | 0.19 |      | 0.20       | 0.24 |      | 0.30                 | 0.37 |      | 0.30                | 0.37 |      | 0.37      | 0.45 |      | 0.61                 | 0.75 |      |
| HE500B  | 0.15               | 0.19 | 0.21 | 0.20       | 0.24 | 0.27 | 0.30                 | 0.37 | 0.42 | 0.30                | 0.37 | 0.42 | 0.36      | 0.44 | 0.51 | 0.60                 | 0.74 | 0.84 |



**Table A1.9:** Ratio  $M_{\text{splice}}/M_{\text{Rd}}$ ,  $L = 6 \text{ m}$ ,  $H_{\text{spl}} = 0.1L$

| Section | Fixed-fixed column |      |      |            |      |      | Pinned-pinned column |      |      | Fixed-guided column |      |      |           |      |      | Pinned-guided column |      |      |
|---------|--------------------|------|------|------------|------|------|----------------------|------|------|---------------------|------|------|-----------|------|------|----------------------|------|------|
|         | $K = 0.5$          |      |      | $K = 0.65$ |      |      | $K = 1.0$            |      |      | $K = 1.0$           |      |      | $K = 1.2$ |      |      | $K = 2.0$            |      |      |
|         | S235               | S355 | S460 | S235       | S355 | S460 | S235                 | S355 | S460 | S235                | S355 | S460 | S235      | S355 | S460 | S235                 | S355 | S460 |
| HE100A  | 0.22               | 0.31 | 0.33 | 0.34       | 0.45 | 0.48 | 0.21                 | 0.24 | 0.25 | 0.65                | 0.74 | 0.77 | 0.73      | 0.80 | 0.83 | 0.14                 | 0.15 | 0.15 |
| HE100B  | 0.21               | 0.30 | 0.31 | 0.33       | 0.43 | 0.47 | 0.21                 | 0.24 | 0.25 | 0.64                | 0.73 | 0.77 | 0.72      | 0.79 | 0.82 | 0.14                 | 0.15 | 0.15 |
| HE120A  | 0.15               | 0.22 | 0.22 | 0.25       | 0.35 | 0.37 | 0.18                 | 0.21 | 0.23 | 0.55                | 0.66 | 0.70 | 0.65      | 0.74 | 0.77 | 0.14                 | 0.14 | 0.15 |
| HE120B  | 0.15               | 0.21 | 0.21 | 0.23       | 0.33 | 0.36 | 0.17                 | 0.21 | 0.22 | 0.53                | 0.64 | 0.69 | 0.63      | 0.73 | 0.76 | 0.14                 | 0.14 | 0.14 |
| HE140A  | 0.11               | 0.17 | 0.16 | 0.19       | 0.27 | 0.28 | 0.15                 | 0.19 | 0.20 | 0.45                | 0.58 | 0.62 | 0.56      | 0.67 | 0.71 | 0.13                 | 0.14 | 0.14 |
| HE140B  | 0.11               | 0.16 | 0.15 | 0.18       | 0.25 | 0.26 | 0.14                 | 0.18 | 0.20 | 0.43                | 0.56 | 0.60 | 0.54      | 0.66 | 0.70 | 0.13                 | 0.14 | 0.14 |
| HE160A  | 0.09               | 0.13 | 0.12 | 0.15       | 0.21 | 0.21 | 0.12                 | 0.16 | 0.17 | 0.37                | 0.49 | 0.54 | 0.48      | 0.60 | 0.65 | 0.12                 | 0.13 | 0.14 |
| HE160B  | 0.08               | 0.12 | 0.11 | 0.14       | 0.20 | 0.19 | 0.11                 | 0.15 | 0.17 | 0.35                | 0.47 | 0.51 | 0.46      | 0.58 | 0.63 | 0.12                 | 0.13 | 0.14 |
| HE180A  | 0.07               | 0.10 | 0.09 | 0.12       | 0.17 | 0.16 | 0.10                 | 0.14 | 0.15 | 0.30                | 0.42 | 0.45 | 0.40      | 0.53 | 0.57 | 0.11                 | 0.13 | 0.13 |
| HE180B  | 0.07               | 0.10 | 0.08 | 0.11       | 0.16 | 0.15 | 0.09                 | 0.13 | 0.14 | 0.28                | 0.40 | 0.43 | 0.38      | 0.51 | 0.55 | 0.11                 | 0.13 | 0.13 |
| HE200A  | 0.06               | 0.08 | 0.07 | 0.09       | 0.14 | 0.12 | 0.08                 | 0.11 | 0.12 | 0.25                | 0.35 | 0.37 | 0.34      | 0.46 | 0.50 | 0.11                 | 0.12 | 0.13 |
| HE200B  | 0.05               | 0.08 | 0.07 | 0.09       | 0.13 | 0.12 | 0.08                 | 0.11 | 0.11 | 0.23                | 0.33 | 0.35 | 0.32      | 0.44 | 0.48 | 0.10                 | 0.12 | 0.12 |
| HE220A  | 0.04               | 0.07 | 0.06 | 0.08       | 0.11 | 0.10 | 0.07                 | 0.10 | 0.10 | 0.20                | 0.30 | 0.30 | 0.28      | 0.40 | 0.43 | 0.10                 | 0.11 | 0.12 |
| HE220B  | 0.04               | 0.07 | 0.05 | 0.07       | 0.11 | 0.09 | 0.06                 | 0.09 | 0.09 | 0.19                | 0.28 | 0.28 | 0.27      | 0.38 | 0.41 | 0.09                 | 0.11 | 0.12 |
| HE240A  | 0.03               | 0.06 | 0.05 | 0.06       | 0.10 | 0.08 | 0.06                 | 0.08 | 0.08 | 0.17                | 0.25 | 0.25 | 0.24      | 0.35 | 0.36 | 0.09                 | 0.11 | 0.11 |
| HE240B  | 0.03               | 0.05 | 0.05 | 0.06       | 0.09 | 0.08 | 0.05                 | 0.08 | 0.08 | 0.16                | 0.24 | 0.23 | 0.23      | 0.33 | 0.35 | 0.08                 | 0.10 | 0.11 |
| HE260A  | 0.03               | 0.05 | 0.04 | 0.05       | 0.08 | 0.07 | 0.05                 | 0.07 | 0.07 | 0.15                | 0.21 | 0.20 | 0.21      | 0.30 | 0.30 | 0.08                 | 0.10 | 0.11 |
| HE260B  | 0.02               | 0.04 | 0.04 | 0.05       | 0.08 | 0.07 | 0.05                 | 0.07 | 0.06 | 0.14                | 0.21 | 0.19 | 0.20      | 0.29 | 0.29 | 0.08                 | 0.10 | 0.10 |
| HE280A  | 0.02               | 0.04 |      | 0.04       | 0.07 |      | 0.04                 | 0.06 |      | 0.13                | 0.19 |      | 0.18      | 0.26 |      | 0.07                 | 0.09 |      |
| HE280B  | 0.02               | 0.04 | 0.03 | 0.04       | 0.07 | 0.06 | 0.04                 | 0.06 | 0.05 | 0.12                | 0.18 | 0.16 | 0.17      | 0.25 | 0.24 | 0.07                 | 0.09 | 0.10 |
| HE300A  | 0.01               | 0.03 | 0.03 | 0.04       | 0.06 | 0.05 | 0.04                 | 0.05 | 0.05 | 0.11                | 0.16 | 0.15 | 0.16      | 0.23 | 0.22 | 0.06                 | 0.08 | 0.09 |
| HE300B  | 0.01               | 0.03 | 0.03 | 0.03       | 0.06 | 0.05 | 0.03                 | 0.05 | 0.05 | 0.11                | 0.16 | 0.14 | 0.15      | 0.22 | 0.21 | 0.06                 | 0.08 | 0.09 |
| HE320A  | 0.01               | 0.03 | 0.02 | 0.03       | 0.05 | 0.04 | 0.03                 | 0.05 | 0.04 | 0.10                | 0.14 | 0.13 | 0.14      | 0.20 | 0.19 | 0.06                 | 0.08 | 0.08 |
| HE320B  | 0.01               | 0.02 | 0.02 | 0.03       | 0.05 | 0.04 | 0.03                 | 0.05 | 0.04 | 0.09                | 0.14 | 0.12 | 0.13      | 0.20 | 0.18 | 0.06                 | 0.08 | 0.08 |
| HE340A  | 0.01               | 0.02 | 0.02 | 0.03       | 0.05 | 0.04 | 0.03                 | 0.04 | 0.04 | 0.09                | 0.13 | 0.11 | 0.12      | 0.18 | 0.17 | 0.05                 | 0.07 | 0.08 |
| HE340B  | 0.01               | 0.02 | 0.02 | 0.02       | 0.04 | 0.04 | 0.03                 | 0.04 | 0.04 | 0.08                | 0.13 | 0.11 | 0.12      | 0.18 | 0.16 | 0.05                 | 0.07 | 0.08 |
| HE360A  | 0.00               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.03                 | 0.04 | 0.03 | 0.08                | 0.12 | 0.10 | 0.11      | 0.16 | 0.15 | 0.05                 | 0.07 | 0.07 |
| HE360B  | 0.00               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.02                 | 0.04 | 0.03 | 0.08                | 0.11 | 0.10 | 0.11      | 0.16 | 0.14 | 0.05                 | 0.06 | 0.07 |
| HE400A  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.01                 | 0.02 | 0.02 | 0.04                | 0.06 | 0.05 | 0.06      | 0.09 | 0.08 | 0.03                 | 0.05 | 0.05 |
| HE400B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.01                 | 0.02 | 0.02 | 0.04                | 0.06 | 0.05 | 0.06      | 0.09 | 0.08 | 0.03                 | 0.04 | 0.05 |
| HE450A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.01                 | 0.02 | 0.01 | 0.03                | 0.05 | 0.04 | 0.05      | 0.07 | 0.06 | 0.02                 | 0.03 | 0.04 |
| HE450B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.01                 | 0.02 | 0.01 | 0.03                | 0.05 | 0.04 | 0.05      | 0.07 | 0.06 | 0.02                 | 0.03 | 0.04 |
| HE500A  | 0.00               | 0.00 |      | 0.00       | 0.01 |      | 0.01                 | 0.01 |      | 0.02                | 0.04 |      | 0.04      | 0.06 |      | 0.02                 | 0.03 |      |
| HE500B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.01                 | 0.01 | 0.01 | 0.02                | 0.04 | 0.03 | 0.04      | 0.06 | 0.05 | 0.02                 | 0.03 | 0.03 |

**Table A1.10:** Ratio  $M_{\text{splice}}/M_{\text{Rd}}$ ,  $L = 6 \text{ m}$ ,  $H_{\text{spl}} = 0.2L$ 

| Section | Fixed-fixed column |      |      |            |      |      | Pinned-pinned column |      |      | Fixed-guided column |      |      |           |      |      | Pinned-guided column |      |      |
|---------|--------------------|------|------|------------|------|------|----------------------|------|------|---------------------|------|------|-----------|------|------|----------------------|------|------|
|         | $K = 0.5$          |      |      | $K = 0.65$ |      |      | $K = 1.0$            |      |      | $K = 1.0$           |      |      | $K = 1.2$ |      |      | $K = 2.0$            |      |      |
|         | S235               | S355 | S460 | S235       | S355 | S460 | S235                 | S355 | S460 | S235                | S355 | S460 | S235      | S355 | S460 | S235                 | S355 | S460 |
| HE100A  | 0.08               | 0.12 | 0.13 | 0.13       | 0.17 | 0.18 | 0.40                 | 0.46 | 0.48 | 0.55                | 0.63 | 0.66 | 0.62      | 0.68 | 0.70 | 0.28                 | 0.29 | 0.29 |
| HE100B  | 0.08               | 0.11 | 0.12 | 0.12       | 0.17 | 0.18 | 0.39                 | 0.45 | 0.47 | 0.54                | 0.62 | 0.65 | 0.61      | 0.67 | 0.70 | 0.28                 | 0.29 | 0.29 |
| HE120A  | 0.06               | 0.09 | 0.08 | 0.09       | 0.13 | 0.14 | 0.34                 | 0.41 | 0.43 | 0.47                | 0.56 | 0.60 | 0.55      | 0.63 | 0.66 | 0.27                 | 0.28 | 0.29 |
| HE120B  | 0.06               | 0.08 | 0.08 | 0.09       | 0.13 | 0.14 | 0.33                 | 0.40 | 0.42 | 0.45                | 0.55 | 0.58 | 0.54      | 0.62 | 0.65 | 0.27                 | 0.28 | 0.29 |
| HE140A  | 0.04               | 0.06 | 0.06 | 0.07       | 0.10 | 0.11 | 0.28                 | 0.36 | 0.38 | 0.38                | 0.49 | 0.53 | 0.48      | 0.57 | 0.61 | 0.26                 | 0.27 | 0.28 |
| HE140B  | 0.04               | 0.06 | 0.06 | 0.07       | 0.10 | 0.10 | 0.27                 | 0.34 | 0.37 | 0.37                | 0.47 | 0.51 | 0.46      | 0.56 | 0.59 | 0.25                 | 0.27 | 0.28 |
| HE160A  | 0.03               | 0.05 | 0.04 | 0.06       | 0.08 | 0.08 | 0.23                 | 0.31 | 0.33 | 0.31                | 0.42 | 0.46 | 0.41      | 0.51 | 0.55 | 0.24                 | 0.26 | 0.27 |
| HE160B  | 0.03               | 0.05 | 0.04 | 0.05       | 0.08 | 0.07 | 0.22                 | 0.29 | 0.32 | 0.30                | 0.40 | 0.44 | 0.39      | 0.50 | 0.53 | 0.24                 | 0.26 | 0.27 |
| HE180A  | 0.03               | 0.04 | 0.03 | 0.04       | 0.06 | 0.06 | 0.18                 | 0.26 | 0.28 | 0.25                | 0.35 | 0.38 | 0.34      | 0.45 | 0.49 | 0.22                 | 0.25 | 0.26 |
| HE180B  | 0.02               | 0.04 | 0.03 | 0.04       | 0.06 | 0.06 | 0.17                 | 0.25 | 0.26 | 0.24                | 0.34 | 0.36 | 0.33      | 0.44 | 0.47 | 0.22                 | 0.25 | 0.26 |
| HE200A  | 0.02               | 0.03 | 0.03 | 0.04       | 0.05 | 0.05 | 0.15                 | 0.22 | 0.23 | 0.21                | 0.30 | 0.32 | 0.29      | 0.39 | 0.43 | 0.21                 | 0.24 | 0.25 |
| HE200B  | 0.02               | 0.03 | 0.03 | 0.03       | 0.05 | 0.04 | 0.14                 | 0.21 | 0.22 | 0.20                | 0.28 | 0.30 | 0.27      | 0.38 | 0.41 | 0.20                 | 0.23 | 0.25 |
| HE220A  | 0.02               | 0.03 | 0.02 | 0.03       | 0.04 | 0.04 | 0.13                 | 0.18 | 0.19 | 0.17                | 0.25 | 0.26 | 0.24      | 0.34 | 0.36 | 0.19                 | 0.22 | 0.24 |
| HE220B  | 0.02               | 0.02 | 0.02 | 0.03       | 0.04 | 0.04 | 0.12                 | 0.17 | 0.18 | 0.16                | 0.24 | 0.24 | 0.23      | 0.33 | 0.35 | 0.19                 | 0.22 | 0.23 |
| HE240A  | 0.01               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.11                 | 0.16 | 0.15 | 0.15                | 0.21 | 0.21 | 0.20      | 0.29 | 0.31 | 0.17                 | 0.21 | 0.22 |
| HE240B  | 0.01               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.10                 | 0.15 | 0.14 | 0.14                | 0.20 | 0.20 | 0.20      | 0.28 | 0.29 | 0.17                 | 0.21 | 0.22 |
| HE260A  | 0.01               | 0.02 | 0.02 | 0.02       | 0.03 | 0.03 | 0.09                 | 0.13 | 0.13 | 0.12                | 0.18 | 0.17 | 0.17      | 0.25 | 0.26 | 0.16                 | 0.20 | 0.21 |
| HE260B  | 0.01               | 0.02 | 0.01 | 0.02       | 0.03 | 0.03 | 0.09                 | 0.13 | 0.12 | 0.12                | 0.17 | 0.16 | 0.17      | 0.24 | 0.25 | 0.15                 | 0.19 | 0.21 |
| HE280A  | 0.01               | 0.01 |      | 0.02       | 0.03 |      | 0.08                 | 0.11 |      | 0.11                | 0.16 |      | 0.15      | 0.22 |      | 0.14                 | 0.18 |      |
| HE280B  | 0.01               | 0.01 | 0.01 | 0.02       | 0.03 | 0.02 | 0.08                 | 0.11 | 0.10 | 0.10                | 0.15 | 0.14 | 0.15      | 0.21 | 0.21 | 0.14                 | 0.18 | 0.19 |
| HE300A  | 0.01               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.07                 | 0.10 | 0.09 | 0.09                | 0.14 | 0.12 | 0.13      | 0.19 | 0.19 | 0.13                 | 0.17 | 0.18 |
| HE300B  | 0.01               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.07                 | 0.10 | 0.09 | 0.09                | 0.13 | 0.12 | 0.13      | 0.19 | 0.18 | 0.12                 | 0.16 | 0.18 |
| HE320A  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.06                 | 0.09 | 0.08 | 0.08                | 0.12 | 0.11 | 0.12      | 0.17 | 0.16 | 0.11                 | 0.15 | 0.17 |
| HE320B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.06                 | 0.09 | 0.08 | 0.08                | 0.12 | 0.10 | 0.11      | 0.17 | 0.15 | 0.11                 | 0.15 | 0.16 |
| HE340A  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.01 | 0.05                 | 0.08 | 0.07 | 0.07                | 0.11 | 0.10 | 0.11      | 0.15 | 0.14 | 0.10                 | 0.14 | 0.15 |
| HE340B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.01 | 0.05                 | 0.08 | 0.07 | 0.07                | 0.11 | 0.09 | 0.10      | 0.15 | 0.14 | 0.10                 | 0.14 | 0.15 |
| HE360A  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.01 | 0.05                 | 0.07 | 0.06 | 0.07                | 0.10 | 0.09 | 0.09      | 0.14 | 0.12 | 0.09                 | 0.13 | 0.14 |
| HE360B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.01 | 0.01 | 0.05                 | 0.07 | 0.06 | 0.06                | 0.10 | 0.08 | 0.09      | 0.14 | 0.12 | 0.09                 | 0.13 | 0.14 |
| HE400A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.02                 | 0.04 | 0.03 | 0.03                | 0.05 | 0.04 | 0.05      | 0.08 | 0.07 | 0.06                 | 0.09 | 0.10 |
| HE400B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.02                 | 0.04 | 0.03 | 0.03                | 0.05 | 0.04 | 0.05      | 0.07 | 0.06 | 0.05                 | 0.09 | 0.10 |
| HE450A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.02                 | 0.03 | 0.03 | 0.03                | 0.04 | 0.03 | 0.04      | 0.06 | 0.05 | 0.04                 | 0.07 | 0.07 |
| HE450B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.02                 | 0.03 | 0.02 | 0.02                | 0.04 | 0.03 | 0.04      | 0.06 | 0.05 | 0.04                 | 0.07 | 0.07 |
| HE500A  | 0.00               | 0.00 |      | 0.00       | 0.00 |      | 0.01                 | 0.02 |      | 0.02                | 0.03 |      | 0.03      | 0.05 |      | 0.04                 | 0.05 |      |
| HE500B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.01                 | 0.02 | 0.02 | 0.02                | 0.03 | 0.03 | 0.03      | 0.05 | 0.04 | 0.03                 | 0.05 | 0.05 |



**Table A1.11:** Ratio  $M_{\text{splice}}/M_{\text{Rd}}$ ,  $L = 6 \text{ m}$ ,  $H_{\text{spl}} = 0.4L$

| Section | Fixed-fixed column |      |      |            |      |      | Pinned-pinned column |      |      | Fixed-guided column |      |      |           |      |      | Pinned-guided column |      |      |
|---------|--------------------|------|------|------------|------|------|----------------------|------|------|---------------------|------|------|-----------|------|------|----------------------|------|------|
|         | $K = 0.5$          |      |      | $K = 0.65$ |      |      | $K = 1.0$            |      |      | $K = 1.0$           |      |      | $K = 1.2$ |      |      | $K = 2.0$            |      |      |
|         | S235               | S355 | S460 | S235       | S355 | S460 | S235                 | S355 | S460 | S235                | S355 | S460 | S235      | S355 | S460 | S235                 | S355 | S460 |
| HE100A  | 0.22               | 0.31 | 0.33 | 0.34       | 0.45 | 0.48 | 0.65                 | 0.74 | 0.77 | 0.21                | 0.24 | 0.25 | 0.24      | 0.26 | 0.27 | 0.53                 | 0.55 | 0.56 |
| HE100B  | 0.21               | 0.30 | 0.31 | 0.33       | 0.43 | 0.47 | 0.64                 | 0.73 | 0.77 | 0.21                | 0.24 | 0.25 | 0.23      | 0.26 | 0.27 | 0.53                 | 0.55 | 0.56 |
| HE120A  | 0.15               | 0.22 | 0.22 | 0.25       | 0.35 | 0.37 | 0.55                 | 0.66 | 0.70 | 0.18                | 0.21 | 0.23 | 0.21      | 0.24 | 0.25 | 0.51                 | 0.54 | 0.55 |
| HE120B  | 0.15               | 0.21 | 0.21 | 0.23       | 0.33 | 0.36 | 0.53                 | 0.64 | 0.69 | 0.17                | 0.21 | 0.22 | 0.21      | 0.24 | 0.25 | 0.51                 | 0.53 | 0.54 |
| HE140A  | 0.11               | 0.17 | 0.16 | 0.19       | 0.27 | 0.28 | 0.45                 | 0.58 | 0.62 | 0.15                | 0.19 | 0.20 | 0.18      | 0.22 | 0.23 | 0.49                 | 0.52 | 0.53 |
| HE140B  | 0.11               | 0.16 | 0.15 | 0.18       | 0.25 | 0.26 | 0.43                 | 0.56 | 0.60 | 0.14                | 0.18 | 0.20 | 0.18      | 0.21 | 0.23 | 0.48                 | 0.51 | 0.53 |
| HE160A  | 0.09               | 0.13 | 0.12 | 0.15       | 0.21 | 0.21 | 0.37                 | 0.49 | 0.54 | 0.12                | 0.16 | 0.17 | 0.16      | 0.20 | 0.21 | 0.46                 | 0.50 | 0.51 |
| HE160B  | 0.08               | 0.12 | 0.11 | 0.14       | 0.20 | 0.19 | 0.35                 | 0.47 | 0.51 | 0.11                | 0.15 | 0.17 | 0.15      | 0.19 | 0.20 | 0.45                 | 0.49 | 0.51 |
| HE180A  | 0.07               | 0.10 | 0.09 | 0.12       | 0.17 | 0.16 | 0.30                 | 0.42 | 0.45 | 0.10                | 0.14 | 0.15 | 0.13      | 0.17 | 0.19 | 0.43                 | 0.48 | 0.49 |
| HE180B  | 0.07               | 0.10 | 0.08 | 0.11       | 0.16 | 0.15 | 0.28                 | 0.40 | 0.43 | 0.09                | 0.13 | 0.14 | 0.12      | 0.17 | 0.18 | 0.42                 | 0.47 | 0.49 |
| HE200A  | 0.06               | 0.08 | 0.07 | 0.09       | 0.14 | 0.12 | 0.25                 | 0.35 | 0.37 | 0.08                | 0.11 | 0.12 | 0.11      | 0.15 | 0.16 | 0.40                 | 0.45 | 0.47 |
| HE200B  | 0.05               | 0.08 | 0.07 | 0.09       | 0.13 | 0.12 | 0.23                 | 0.33 | 0.35 | 0.08                | 0.11 | 0.11 | 0.10      | 0.14 | 0.16 | 0.39                 | 0.45 | 0.47 |
| HE220A  | 0.04               | 0.07 | 0.06 | 0.08       | 0.11 | 0.10 | 0.20                 | 0.30 | 0.30 | 0.07                | 0.10 | 0.10 | 0.09      | 0.13 | 0.14 | 0.36                 | 0.43 | 0.45 |
| HE220B  | 0.04               | 0.07 | 0.05 | 0.07       | 0.11 | 0.09 | 0.19                 | 0.28 | 0.28 | 0.06                | 0.09 | 0.09 | 0.09      | 0.12 | 0.13 | 0.35                 | 0.42 | 0.44 |
| HE240A  | 0.03               | 0.06 | 0.05 | 0.06       | 0.10 | 0.08 | 0.17                 | 0.25 | 0.25 | 0.06                | 0.08 | 0.08 | 0.08      | 0.11 | 0.12 | 0.33                 | 0.40 | 0.43 |
| HE240B  | 0.03               | 0.05 | 0.05 | 0.06       | 0.09 | 0.08 | 0.16                 | 0.24 | 0.23 | 0.05                | 0.08 | 0.08 | 0.07      | 0.11 | 0.11 | 0.32                 | 0.39 | 0.42 |
| HE260A  | 0.03               | 0.05 | 0.04 | 0.05       | 0.08 | 0.07 | 0.15                 | 0.21 | 0.20 | 0.05                | 0.07 | 0.07 | 0.07      | 0.10 | 0.10 | 0.30                 | 0.37 | 0.40 |
| HE260B  | 0.02               | 0.04 | 0.04 | 0.05       | 0.08 | 0.07 | 0.14                 | 0.21 | 0.19 | 0.05                | 0.07 | 0.06 | 0.06      | 0.09 | 0.09 | 0.29                 | 0.36 | 0.39 |
| HE280A  | 0.02               | 0.04 |      | 0.04       | 0.07 |      | 0.13                 | 0.19 |      | 0.04                | 0.06 |      | 0.06      | 0.08 |      | 0.27                 | 0.34 |      |
| HE280B  | 0.02               | 0.04 | 0.03 | 0.04       | 0.07 | 0.06 | 0.12                 | 0.18 | 0.16 | 0.04                | 0.06 | 0.05 | 0.06      | 0.08 | 0.08 | 0.26                 | 0.34 | 0.36 |
| HE300A  | 0.01               | 0.03 | 0.03 | 0.04       | 0.06 | 0.05 | 0.11                 | 0.16 | 0.15 | 0.04                | 0.05 | 0.05 | 0.05      | 0.07 | 0.07 | 0.24                 | 0.32 | 0.34 |
| HE300B  | 0.01               | 0.03 | 0.03 | 0.03       | 0.06 | 0.05 | 0.11                 | 0.16 | 0.14 | 0.03                | 0.05 | 0.05 | 0.05      | 0.07 | 0.07 | 0.23                 | 0.31 | 0.34 |
| HE320A  | 0.01               | 0.03 | 0.02 | 0.03       | 0.05 | 0.04 | 0.10                 | 0.14 | 0.13 | 0.03                | 0.05 | 0.04 | 0.04      | 0.07 | 0.06 | 0.21                 | 0.29 | 0.32 |
| HE320B  | 0.01               | 0.02 | 0.02 | 0.03       | 0.05 | 0.04 | 0.09                 | 0.14 | 0.12 | 0.03                | 0.05 | 0.04 | 0.04      | 0.06 | 0.06 | 0.21                 | 0.29 | 0.31 |
| HE340A  | 0.01               | 0.02 | 0.02 | 0.03       | 0.05 | 0.04 | 0.09                 | 0.13 | 0.11 | 0.03                | 0.04 | 0.04 | 0.04      | 0.06 | 0.05 | 0.19                 | 0.27 | 0.29 |
| HE340B  | 0.01               | 0.02 | 0.02 | 0.02       | 0.04 | 0.04 | 0.08                 | 0.13 | 0.11 | 0.03                | 0.04 | 0.04 | 0.04      | 0.06 | 0.05 | 0.19                 | 0.26 | 0.28 |
| HE360A  | 0.00               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.08                 | 0.12 | 0.10 | 0.03                | 0.04 | 0.03 | 0.04      | 0.05 | 0.05 | 0.18                 | 0.25 | 0.27 |
| HE360B  | 0.00               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.08                 | 0.11 | 0.10 | 0.02                | 0.04 | 0.03 | 0.04      | 0.05 | 0.05 | 0.17                 | 0.24 | 0.26 |
| HE400A  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.04                 | 0.06 | 0.05 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.03 | 0.11                 | 0.17 | 0.19 |
| HE400B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.04                 | 0.06 | 0.05 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.02 | 0.10                 | 0.16 | 0.18 |
| HE450A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.05 | 0.04 | 0.01                | 0.02 | 0.01 | 0.02      | 0.02 | 0.02 | 0.08                 | 0.13 | 0.14 |
| HE450B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.05 | 0.04 | 0.01                | 0.02 | 0.01 | 0.01      | 0.02 | 0.02 | 0.08                 | 0.13 | 0.13 |
| HE500A  | 0.00               | 0.00 |      | 0.00       | 0.01 |      | 0.02                 | 0.04 |      | 0.01                | 0.01 |      | 0.01      | 0.02 |      | 0.07                 | 0.10 |      |
| HE500B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.02                 | 0.04 | 0.03 | 0.01                | 0.01 | 0.01 | 0.01      | 0.02 | 0.02 | 0.07                 | 0.10 | 0.10 |

**Table A1.12:** Ratio  $M_{\text{splice}}/M_{\text{Rd}}$ ,  $L = 6 \text{ m}$ ,  $H_{\text{spl}} = 0.6L$ 

| Section | Fixed-fixed column |      |      |            |      |      | Pinned-pinned column |      |      | Fixed-guided column |      |      |           |      |      | Pinned-guided column |      |      |
|---------|--------------------|------|------|------------|------|------|----------------------|------|------|---------------------|------|------|-----------|------|------|----------------------|------|------|
|         | $K = 0.5$          |      |      | $K = 0.65$ |      |      | $K = 1.0$            |      |      | $K = 1.0$           |      |      | $K = 1.2$ |      |      | $K = 2.0$            |      |      |
|         | S235               | S355 | S460 | S235       | S355 | S460 | S235                 | S355 | S460 | S235                | S355 | S460 | S235      | S355 | S460 | S235                 | S355 | S460 |
| HE100A  | 0.22               | 0.31 | 0.33 | 0.34       | 0.45 | 0.48 | 0.65                 | 0.74 | 0.77 | 0.21                | 0.24 | 0.25 | 0.24      | 0.26 | 0.27 | 0.74                 | 0.76 | 0.77 |
| HE100B  | 0.21               | 0.30 | 0.31 | 0.33       | 0.43 | 0.47 | 0.64                 | 0.73 | 0.77 | 0.21                | 0.24 | 0.25 | 0.23      | 0.26 | 0.27 | 0.73                 | 0.76 | 0.77 |
| HE120A  | 0.15               | 0.22 | 0.22 | 0.25       | 0.35 | 0.37 | 0.55                 | 0.66 | 0.70 | 0.18                | 0.21 | 0.23 | 0.21      | 0.24 | 0.25 | 0.70                 | 0.74 | 0.75 |
| HE120B  | 0.15               | 0.21 | 0.21 | 0.23       | 0.33 | 0.36 | 0.53                 | 0.64 | 0.69 | 0.17                | 0.21 | 0.22 | 0.21      | 0.24 | 0.25 | 0.70                 | 0.73 | 0.75 |
| HE140A  | 0.11               | 0.17 | 0.16 | 0.19       | 0.27 | 0.28 | 0.45                 | 0.58 | 0.62 | 0.15                | 0.19 | 0.20 | 0.18      | 0.22 | 0.23 | 0.67                 | 0.71 | 0.73 |
| HE140B  | 0.11               | 0.16 | 0.15 | 0.18       | 0.25 | 0.26 | 0.43                 | 0.56 | 0.60 | 0.14                | 0.18 | 0.20 | 0.18      | 0.21 | 0.23 | 0.66                 | 0.71 | 0.73 |
| HE160A  | 0.09               | 0.13 | 0.12 | 0.15       | 0.21 | 0.21 | 0.37                 | 0.49 | 0.54 | 0.12                | 0.16 | 0.17 | 0.16      | 0.20 | 0.21 | 0.63                 | 0.69 | 0.71 |
| HE160B  | 0.08               | 0.12 | 0.11 | 0.14       | 0.20 | 0.19 | 0.35                 | 0.47 | 0.51 | 0.11                | 0.15 | 0.17 | 0.15      | 0.19 | 0.20 | 0.62                 | 0.68 | 0.70 |
| HE180A  | 0.07               | 0.10 | 0.09 | 0.12       | 0.17 | 0.16 | 0.30                 | 0.42 | 0.45 | 0.10                | 0.14 | 0.15 | 0.13      | 0.17 | 0.19 | 0.59                 | 0.66 | 0.68 |
| HE180B  | 0.07               | 0.10 | 0.08 | 0.11       | 0.16 | 0.15 | 0.28                 | 0.40 | 0.43 | 0.09                | 0.13 | 0.14 | 0.12      | 0.17 | 0.18 | 0.58                 | 0.65 | 0.67 |
| HE200A  | 0.06               | 0.08 | 0.07 | 0.09       | 0.14 | 0.12 | 0.25                 | 0.35 | 0.37 | 0.08                | 0.11 | 0.12 | 0.11      | 0.15 | 0.16 | 0.54                 | 0.62 | 0.65 |
| HE200B  | 0.05               | 0.08 | 0.07 | 0.09       | 0.13 | 0.12 | 0.23                 | 0.33 | 0.35 | 0.08                | 0.11 | 0.11 | 0.10      | 0.14 | 0.16 | 0.53                 | 0.61 | 0.64 |
| HE220A  | 0.04               | 0.07 | 0.06 | 0.08       | 0.11 | 0.10 | 0.20                 | 0.30 | 0.30 | 0.07                | 0.10 | 0.10 | 0.09      | 0.13 | 0.14 | 0.50                 | 0.59 | 0.62 |
| HE220B  | 0.04               | 0.07 | 0.05 | 0.07       | 0.11 | 0.09 | 0.19                 | 0.28 | 0.28 | 0.06                | 0.09 | 0.09 | 0.09      | 0.12 | 0.13 | 0.48                 | 0.58 | 0.61 |
| HE240A  | 0.03               | 0.06 | 0.05 | 0.06       | 0.10 | 0.08 | 0.17                 | 0.25 | 0.25 | 0.06                | 0.08 | 0.08 | 0.08      | 0.11 | 0.12 | 0.45                 | 0.55 | 0.59 |
| HE240B  | 0.03               | 0.05 | 0.05 | 0.06       | 0.09 | 0.08 | 0.16                 | 0.24 | 0.23 | 0.05                | 0.08 | 0.08 | 0.07      | 0.11 | 0.11 | 0.44                 | 0.54 | 0.58 |
| HE260A  | 0.03               | 0.05 | 0.04 | 0.05       | 0.08 | 0.07 | 0.15                 | 0.21 | 0.20 | 0.05                | 0.07 | 0.07 | 0.07      | 0.10 | 0.10 | 0.41                 | 0.51 | 0.55 |
| HE260B  | 0.02               | 0.04 | 0.04 | 0.05       | 0.08 | 0.07 | 0.14                 | 0.21 | 0.19 | 0.05                | 0.07 | 0.06 | 0.06      | 0.09 | 0.09 | 0.39                 | 0.50 | 0.54 |
| HE280A  | 0.02               | 0.04 |      | 0.04       | 0.07 |      | 0.13                 | 0.19 |      | 0.04                | 0.06 |      | 0.06      | 0.08 |      | 0.37                 | 0.47 |      |
| HE280B  | 0.02               | 0.04 | 0.03 | 0.04       | 0.07 | 0.06 | 0.12                 | 0.18 | 0.16 | 0.04                | 0.06 | 0.05 | 0.06      | 0.08 | 0.08 | 0.35                 | 0.46 | 0.50 |
| HE300A  | 0.01               | 0.03 | 0.03 | 0.04       | 0.06 | 0.05 | 0.11                 | 0.16 | 0.15 | 0.04                | 0.05 | 0.05 | 0.05      | 0.07 | 0.07 | 0.33                 | 0.44 | 0.47 |
| HE300B  | 0.01               | 0.03 | 0.03 | 0.03       | 0.06 | 0.05 | 0.11                 | 0.16 | 0.14 | 0.03                | 0.05 | 0.05 | 0.05      | 0.07 | 0.07 | 0.32                 | 0.43 | 0.46 |
| HE320A  | 0.01               | 0.03 | 0.02 | 0.03       | 0.05 | 0.04 | 0.10                 | 0.14 | 0.13 | 0.03                | 0.05 | 0.04 | 0.04      | 0.07 | 0.06 | 0.30                 | 0.40 | 0.44 |
| HE320B  | 0.01               | 0.02 | 0.02 | 0.03       | 0.05 | 0.04 | 0.09                 | 0.14 | 0.12 | 0.03                | 0.05 | 0.04 | 0.04      | 0.06 | 0.06 | 0.29                 | 0.39 | 0.43 |
| HE340A  | 0.01               | 0.02 | 0.02 | 0.03       | 0.05 | 0.04 | 0.09                 | 0.13 | 0.11 | 0.03                | 0.04 | 0.04 | 0.04      | 0.06 | 0.05 | 0.27                 | 0.37 | 0.40 |
| HE340B  | 0.01               | 0.02 | 0.02 | 0.02       | 0.04 | 0.04 | 0.08                 | 0.13 | 0.11 | 0.03                | 0.04 | 0.04 | 0.04      | 0.06 | 0.05 | 0.26                 | 0.36 | 0.39 |
| HE360A  | 0.00               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.08                 | 0.12 | 0.10 | 0.03                | 0.04 | 0.03 | 0.04      | 0.05 | 0.05 | 0.24                 | 0.34 | 0.37 |
| HE360B  | 0.00               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.08                 | 0.11 | 0.10 | 0.02                | 0.04 | 0.03 | 0.04      | 0.05 | 0.05 | 0.24                 | 0.33 | 0.36 |
| HE400A  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.04                 | 0.06 | 0.05 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.03 | 0.15                 | 0.23 | 0.26 |
| HE400B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.04                 | 0.06 | 0.05 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.02 | 0.14                 | 0.23 | 0.25 |
| HE450A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.05 | 0.04 | 0.01                | 0.02 | 0.01 | 0.02      | 0.02 | 0.02 | 0.11                 | 0.18 | 0.19 |
| HE450B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.05 | 0.04 | 0.01                | 0.02 | 0.01 | 0.01      | 0.02 | 0.02 | 0.11                 | 0.17 | 0.18 |
| HE500A  | 0.00               | 0.00 |      | 0.00       | 0.01 |      | 0.02                 | 0.04 |      | 0.01                | 0.01 |      | 0.01      | 0.02 |      | 0.09                 | 0.14 |      |
| HE500B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.02                 | 0.04 | 0.03 | 0.01                | 0.01 | 0.01 | 0.01      | 0.02 | 0.02 | 0.09                 | 0.14 | 0.14 |



**Table A1.13:** Ratio  $M_{\text{splice}}/M_{\text{Rd}}$ ,  $L = 6 \text{ m}$ ,  $H_{\text{spl}} = 0.8L$

| Section | Fixed-fixed column |      |      |            |      |      | Pinned-pinned column |      |      | Fixed-guided column |      |      |           |      |      | Pinned-guided column |      |      |
|---------|--------------------|------|------|------------|------|------|----------------------|------|------|---------------------|------|------|-----------|------|------|----------------------|------|------|
|         | $K = 0.5$          |      |      | $K = 0.65$ |      |      | $K = 1.0$            |      |      | $K = 1.0$           |      |      | $K = 1.2$ |      |      | $K = 2.0$            |      |      |
|         | S235               | S355 | S460 | S235       | S355 | S460 | S235                 | S355 | S460 | S235                | S355 | S460 | S235      | S355 | S460 | S235                 | S355 | S460 |
| HE100A  | 0.08               | 0.12 | 0.13 | 0.13       | 0.17 | 0.18 | 0.40                 | 0.46 | 0.48 | 0.55                | 0.63 | 0.66 | 0.62      | 0.68 | 0.70 | 0.86                 | 0.89 | 0.90 |
| HE100B  | 0.08               | 0.11 | 0.12 | 0.12       | 0.17 | 0.18 | 0.39                 | 0.45 | 0.47 | 0.54                | 0.62 | 0.65 | 0.61      | 0.67 | 0.70 | 0.86                 | 0.89 | 0.90 |
| HE120A  | 0.06               | 0.09 | 0.08 | 0.09       | 0.13 | 0.14 | 0.34                 | 0.41 | 0.43 | 0.47                | 0.56 | 0.60 | 0.55      | 0.63 | 0.66 | 0.83                 | 0.87 | 0.88 |
| HE120B  | 0.06               | 0.08 | 0.08 | 0.09       | 0.13 | 0.14 | 0.33                 | 0.40 | 0.42 | 0.45                | 0.55 | 0.58 | 0.54      | 0.62 | 0.65 | 0.82                 | 0.86 | 0.88 |
| HE140A  | 0.04               | 0.06 | 0.06 | 0.07       | 0.10 | 0.11 | 0.28                 | 0.36 | 0.38 | 0.38                | 0.49 | 0.53 | 0.48      | 0.57 | 0.61 | 0.79                 | 0.84 | 0.86 |
| HE140B  | 0.04               | 0.06 | 0.06 | 0.07       | 0.10 | 0.10 | 0.27                 | 0.34 | 0.37 | 0.37                | 0.47 | 0.51 | 0.46      | 0.56 | 0.59 | 0.78                 | 0.83 | 0.85 |
| HE160A  | 0.03               | 0.05 | 0.04 | 0.06       | 0.08 | 0.08 | 0.23                 | 0.31 | 0.33 | 0.31                | 0.42 | 0.46 | 0.41      | 0.51 | 0.55 | 0.74                 | 0.81 | 0.83 |
| HE160B  | 0.03               | 0.05 | 0.04 | 0.05       | 0.08 | 0.07 | 0.22                 | 0.29 | 0.32 | 0.30                | 0.40 | 0.44 | 0.39      | 0.50 | 0.53 | 0.73                 | 0.80 | 0.83 |
| HE180A  | 0.03               | 0.04 | 0.03 | 0.04       | 0.06 | 0.06 | 0.18                 | 0.26 | 0.28 | 0.25                | 0.35 | 0.38 | 0.34      | 0.45 | 0.49 | 0.69                 | 0.77 | 0.80 |
| HE180B  | 0.02               | 0.04 | 0.03 | 0.04       | 0.06 | 0.06 | 0.17                 | 0.25 | 0.26 | 0.24                | 0.34 | 0.36 | 0.33      | 0.44 | 0.47 | 0.68                 | 0.76 | 0.79 |
| HE200A  | 0.02               | 0.03 | 0.03 | 0.04       | 0.05 | 0.05 | 0.15                 | 0.22 | 0.23 | 0.21                | 0.30 | 0.32 | 0.29      | 0.39 | 0.43 | 0.64                 | 0.73 | 0.77 |
| HE200B  | 0.02               | 0.03 | 0.03 | 0.03       | 0.05 | 0.04 | 0.14                 | 0.21 | 0.22 | 0.20                | 0.28 | 0.30 | 0.27      | 0.38 | 0.41 | 0.62                 | 0.72 | 0.76 |
| HE220A  | 0.02               | 0.03 | 0.02 | 0.03       | 0.04 | 0.04 | 0.13                 | 0.18 | 0.19 | 0.17                | 0.25 | 0.26 | 0.24      | 0.34 | 0.36 | 0.59                 | 0.69 | 0.73 |
| HE220B  | 0.02               | 0.02 | 0.02 | 0.03       | 0.04 | 0.04 | 0.12                 | 0.17 | 0.18 | 0.16                | 0.24 | 0.24 | 0.23      | 0.33 | 0.35 | 0.57                 | 0.68 | 0.72 |
| HE240A  | 0.01               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.11                 | 0.16 | 0.15 | 0.15                | 0.21 | 0.21 | 0.20      | 0.29 | 0.31 | 0.53                 | 0.65 | 0.69 |
| HE240B  | 0.01               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.10                 | 0.15 | 0.14 | 0.14                | 0.20 | 0.20 | 0.20      | 0.28 | 0.29 | 0.52                 | 0.63 | 0.68 |
| HE260A  | 0.01               | 0.02 | 0.02 | 0.02       | 0.03 | 0.03 | 0.09                 | 0.13 | 0.13 | 0.12                | 0.18 | 0.17 | 0.17      | 0.25 | 0.26 | 0.48                 | 0.60 | 0.64 |
| HE260B  | 0.01               | 0.02 | 0.01 | 0.02       | 0.03 | 0.03 | 0.09                 | 0.13 | 0.12 | 0.12                | 0.17 | 0.16 | 0.17      | 0.24 | 0.25 | 0.46                 | 0.59 | 0.63 |
| HE280A  | 0.01               | 0.01 |      | 0.02       | 0.03 |      | 0.08                 | 0.11 |      | 0.11                | 0.16 |      | 0.15      | 0.22 |      | 0.43                 | 0.56 |      |
| HE280B  | 0.01               | 0.01 | 0.01 | 0.02       | 0.03 | 0.02 | 0.08                 | 0.11 | 0.10 | 0.10                | 0.15 | 0.14 | 0.15      | 0.21 | 0.21 | 0.42                 | 0.54 | 0.59 |
| HE300A  | 0.01               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.07                 | 0.10 | 0.09 | 0.09                | 0.14 | 0.12 | 0.13      | 0.19 | 0.19 | 0.39                 | 0.51 | 0.56 |
| HE300B  | 0.01               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.07                 | 0.10 | 0.09 | 0.09                | 0.13 | 0.12 | 0.13      | 0.19 | 0.18 | 0.37                 | 0.50 | 0.54 |
| HE320A  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.06                 | 0.09 | 0.08 | 0.08                | 0.12 | 0.11 | 0.12      | 0.17 | 0.16 | 0.35                 | 0.47 | 0.51 |
| HE320B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.06                 | 0.09 | 0.08 | 0.08                | 0.12 | 0.10 | 0.11      | 0.17 | 0.15 | 0.34                 | 0.46 | 0.50 |
| HE340A  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.01 | 0.05                 | 0.08 | 0.07 | 0.07                | 0.11 | 0.10 | 0.11      | 0.15 | 0.14 | 0.31                 | 0.44 | 0.47 |
| HE340B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.01 | 0.05                 | 0.08 | 0.07 | 0.07                | 0.11 | 0.09 | 0.10      | 0.15 | 0.14 | 0.31                 | 0.43 | 0.46 |
| HE360A  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.01 | 0.05                 | 0.07 | 0.06 | 0.07                | 0.10 | 0.09 | 0.09      | 0.14 | 0.12 | 0.29                 | 0.40 | 0.43 |
| HE360B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.01 | 0.01 | 0.05                 | 0.07 | 0.06 | 0.06                | 0.10 | 0.08 | 0.09      | 0.14 | 0.12 | 0.28                 | 0.39 | 0.42 |
| HE400A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.02                 | 0.04 | 0.03 | 0.03                | 0.05 | 0.04 | 0.05      | 0.08 | 0.07 | 0.17                 | 0.27 | 0.31 |
| HE400B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.02                 | 0.04 | 0.03 | 0.03                | 0.05 | 0.04 | 0.05      | 0.07 | 0.06 | 0.17                 | 0.27 | 0.30 |
| HE450A  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.02                 | 0.03 | 0.03 | 0.03                | 0.04 | 0.03 | 0.04      | 0.06 | 0.05 | 0.13                 | 0.21 | 0.22 |
| HE450B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.02                 | 0.03 | 0.02 | 0.02                | 0.04 | 0.03 | 0.04      | 0.06 | 0.05 | 0.13                 | 0.21 | 0.22 |
| HE500A  | 0.00               | 0.00 |      | 0.00       | 0.00 |      | 0.01                 | 0.02 |      | 0.02                | 0.03 |      | 0.03      | 0.05 |      | 0.11                 | 0.17 |      |
| HE500B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.00 | 0.00 | 0.01                 | 0.02 | 0.02 | 0.02                | 0.03 | 0.03 | 0.03      | 0.05 | 0.04 | 0.11                 | 0.16 | 0.16 |

Table A1.14: Column slenderness,  $L = 8$  m

| Section | Fixed-fixed column |      |      |            |      |      | Pinned-pinned column |      |      | Fixed-guided column |      |      |           |      |      | Pinned-guided column |      |      |
|---------|--------------------|------|------|------------|------|------|----------------------|------|------|---------------------|------|------|-----------|------|------|----------------------|------|------|
|         | $K = 0.5$          |      |      | $K = 0.65$ |      |      | $K = 1.0$            |      |      | $K = 1.0$           |      |      | $K = 1.2$ |      |      | $K = 2.0$            |      |      |
|         | S235               | S355 | S460 | S235       | S355 | S460 | S235                 | S355 | S460 | S235                | S355 | S460 | S235      | S355 | S460 | S235                 | S355 | S460 |
| HE100A  | 1.05               | 1.29 | 1.47 | 1.36       | 1.68 | 1.91 | 2.10                 | 2.58 | 2.94 | 2.10                | 2.58 | 2.94 | 2.52      | 3.10 | 3.52 | 4.20                 | 5.16 | 5.87 |
| HE100B  | 1.02               | 1.26 | 1.43 | 1.33       | 1.64 | 1.86 | 2.05                 | 2.52 | 2.87 | 2.05                | 2.52 | 2.87 | 2.46      | 3.02 | 3.44 | 4.10                 | 5.04 | 5.73 |
| HE120A  | 0.87               | 1.07 | 1.22 | 1.13       | 1.39 | 1.58 | 1.74                 | 2.14 | 2.43 | 1.74                | 2.14 | 2.43 | 2.09      | 2.57 | 2.92 | 3.48                 | 4.28 | 4.87 |
| HE120B  | 0.84               | 1.04 | 1.18 | 1.10       | 1.35 | 1.54 | 1.69                 | 2.08 | 2.36 | 1.69                | 2.08 | 2.36 | 2.03      | 2.49 | 2.84 | 3.38                 | 4.15 | 4.73 |
| HE140A  | 0.74               | 0.91 | 1.04 | 0.97       | 1.19 | 1.35 | 1.49                 | 1.83 | 2.08 | 1.49                | 1.83 | 2.08 | 1.78      | 2.19 | 2.49 | 2.97                 | 3.65 | 4.16 |
| HE140B  | 0.72               | 0.88 | 1.01 | 0.93       | 1.15 | 1.31 | 1.44                 | 1.77 | 2.01 | 1.44                | 1.77 | 2.01 | 1.73      | 2.12 | 2.41 | 2.88                 | 3.53 | 4.02 |
| HE160A  | 0.65               | 0.80 | 0.91 | 0.84       | 1.04 | 1.18 | 1.30                 | 1.59 | 1.82 | 1.30                | 1.59 | 1.82 | 1.56      | 1.91 | 2.18 | 2.59                 | 3.19 | 3.63 |
| HE160B  | 0.63               | 0.77 | 0.88 | 0.82       | 1.00 | 1.14 | 1.26                 | 1.55 | 1.76 | 1.26                | 1.55 | 1.76 | 1.51      | 1.85 | 2.11 | 2.51                 | 3.09 | 3.52 |
| HE180A  | 0.57               | 0.70 | 0.80 | 0.74       | 0.91 | 1.04 | 1.14                 | 1.41 | 1.60 | 1.14                | 1.41 | 1.60 | 1.37      | 1.69 | 1.92 | 2.29                 | 2.81 | 3.20 |
| HE180B  | 0.56               | 0.68 | 0.78 | 0.72       | 0.89 | 1.01 | 1.11                 | 1.37 | 1.56 | 1.11                | 1.37 | 1.56 | 1.33      | 1.64 | 1.87 | 2.22                 | 2.73 | 3.11 |
| HE200A  | 0.51               | 0.63 | 0.72 | 0.67       | 0.82 | 0.94 | 1.03                 | 1.26 | 1.44 | 1.03                | 1.26 | 1.44 | 1.23      | 1.52 | 1.73 | 2.06                 | 2.53 | 2.88 |
| HE200B  | 0.50               | 0.61 | 0.70 | 0.65       | 0.80 | 0.91 | 1.00                 | 1.23 | 1.40 | 1.00                | 1.23 | 1.40 | 1.20      | 1.47 | 1.67 | 1.99                 | 2.45 | 2.79 |
| HE220A  | 0.46               | 0.57 | 0.65 | 0.60       | 0.74 | 0.84 | 0.93                 | 1.14 | 1.30 | 0.93                | 1.14 | 1.30 | 1.11      | 1.37 | 1.56 | 1.86                 | 2.28 | 2.60 |
| HE220B  | 0.45               | 0.56 | 0.63 | 0.59       | 0.72 | 0.82 | 0.90                 | 1.11 | 1.26 | 0.90                | 1.11 | 1.26 | 1.08      | 1.33 | 1.52 | 1.81                 | 2.22 | 2.53 |
| HE240A  | 0.42               | 0.52 | 0.59 | 0.55       | 0.68 | 0.77 | 0.85                 | 1.04 | 1.19 | 0.85                | 1.04 | 1.19 | 1.02      | 1.25 | 1.42 | 1.69                 | 2.08 | 2.37 |
| HE240B  | 0.41               | 0.51 | 0.58 | 0.54       | 0.66 | 0.75 | 0.83                 | 1.02 | 1.16 | 0.83                | 1.02 | 1.16 | 0.99      | 1.22 | 1.39 | 1.65                 | 2.03 | 2.31 |
| HE260A  | 0.39               | 0.48 | 0.54 | 0.50       | 0.62 | 0.71 | 0.78                 | 0.95 | 1.09 | 0.78                | 0.95 | 1.09 | 0.93      | 1.15 | 1.30 | 1.55                 | 1.91 | 2.17 |
| HE260B  | 0.38               | 0.47 | 0.53 | 0.49       | 0.61 | 0.69 | 0.76                 | 0.93 | 1.06 | 0.76                | 0.93 | 1.06 | 0.91      | 1.12 | 1.27 | 1.52                 | 1.87 | 2.12 |
| HE280A  | 0.36               | 0.44 |      | 0.47       | 0.57 |      | 0.72                 | 0.88 |      | 0.72                | 0.88 |      | 0.86      | 1.06 |      | 1.44                 | 1.77 |      |
| HE280B  | 0.35               | 0.43 | 0.49 | 0.46       | 0.56 | 0.64 | 0.70                 | 0.86 | 0.98 | 0.70                | 0.86 | 0.98 | 0.84      | 1.04 | 1.18 | 1.41                 | 1.73 | 1.97 |
| HE300A  | 0.33               | 0.41 | 0.47 | 0.43       | 0.53 | 0.61 | 0.67                 | 0.82 | 0.94 | 0.67                | 0.82 | 0.94 | 0.80      | 0.99 | 1.12 | 1.34                 | 1.64 | 1.87 |
| HE300B  | 0.33               | 0.40 | 0.46 | 0.43       | 0.52 | 0.60 | 0.66                 | 0.81 | 0.92 | 0.66                | 0.81 | 0.92 | 0.79      | 0.97 | 1.10 | 1.31                 | 1.61 | 1.83 |
| HE320A  | 0.31               | 0.39 | 0.44 | 0.41       | 0.50 | 0.57 | 0.63                 | 0.77 | 0.88 | 0.63                | 0.77 | 0.88 | 0.75      | 0.93 | 1.05 | 1.25                 | 1.54 | 1.76 |
| HE320B  | 0.31               | 0.38 | 0.43 | 0.40       | 0.49 | 0.56 | 0.62                 | 0.76 | 0.86 | 0.62                | 0.76 | 0.86 | 0.74      | 0.91 | 1.03 | 1.23                 | 1.51 | 1.72 |
| HE340A  | 0.30               | 0.36 | 0.41 | 0.38       | 0.47 | 0.54 | 0.59                 | 0.73 | 0.83 | 0.59                | 0.73 | 0.83 | 0.71      | 0.87 | 0.99 | 1.18                 | 1.45 | 1.66 |
| HE340B  | 0.29               | 0.36 | 0.41 | 0.38       | 0.46 | 0.53 | 0.58                 | 0.71 | 0.81 | 0.58                | 0.71 | 0.81 | 0.70      | 0.86 | 0.98 | 1.16                 | 1.43 | 1.63 |
| HE360A  | 0.28               | 0.34 | 0.39 | 0.36       | 0.45 | 0.51 | 0.56                 | 0.69 | 0.78 | 0.56                | 0.69 | 0.78 | 0.67      | 0.83 | 0.94 | 1.12                 | 1.38 | 1.57 |
| HE360B  | 0.28               | 0.34 | 0.39 | 0.36       | 0.44 | 0.50 | 0.55                 | 0.68 | 0.77 | 0.55                | 0.68 | 0.77 | 0.66      | 0.81 | 0.92 | 1.10                 | 1.35 | 1.54 |
| HE400A  | 0.25               | 0.31 | 0.35 | 0.33       | 0.40 | 0.46 | 0.51                 | 0.62 | 0.71 | 0.51                | 0.62 | 0.71 | 0.61      | 0.75 | 0.85 | 1.01                 | 1.24 | 1.42 |
| HE400B  | 0.25               | 0.31 | 0.35 | 0.32       | 0.40 | 0.45 | 0.50                 | 0.61 | 0.70 | 0.50                | 0.61 | 0.70 | 0.60      | 0.74 | 0.84 | 1.00                 | 1.23 | 1.40 |
| HE450A  | 0.23               | 0.28 | 0.31 | 0.29       | 0.36 | 0.41 | 0.45                 | 0.55 | 0.63 | 0.45                | 0.55 | 0.63 | 0.54      | 0.66 | 0.76 | 0.90                 | 1.11 | 1.26 |
| HE450B  | 0.22               | 0.27 | 0.31 | 0.29       | 0.36 | 0.40 | 0.44                 | 0.55 | 0.62 | 0.44                | 0.55 | 0.62 | 0.53      | 0.66 | 0.75 | 0.89                 | 1.09 | 1.25 |
| HE500A  | 0.20               | 0.25 |      | 0.26       | 0.32 |      | 0.41                 | 0.50 |      | 0.41                | 0.50 |      | 0.49      | 0.60 |      | 0.81                 | 1.00 |      |
| HE500B  | 0.20               | 0.25 | 0.28 | 0.26       | 0.32 | 0.37 | 0.40                 | 0.49 | 0.56 | 0.40                | 0.49 | 0.56 | 0.48      | 0.59 | 0.67 | 0.80                 | 0.99 | 1.12 |



**Table A1.15:** Ratio  $M_{\text{splice}}/M_{\text{Rd}}$ ,  $L = 8 \text{ m}$ ,  $H_{\text{spl}} = 0.05L$

| Section | Fixed-fixed column |      |      |            |      |      | Pinned-pinned column |      |      | Fixed-guided column |      |      |           |      |      | Pinned-guided column |      |      |
|---------|--------------------|------|------|------------|------|------|----------------------|------|------|---------------------|------|------|-----------|------|------|----------------------|------|------|
|         | $K = 0.5$          |      |      | $K = 0.65$ |      |      | $K = 1.0$            |      |      | $K = 1.0$           |      |      | $K = 1.2$ |      |      | $K = 2.0$            |      |      |
|         | S235               | S355 | S460 | S235       | S355 | S460 | S235                 | S355 | S460 | S235                | S355 | S460 | S235      | S355 | S460 | S235                 | S355 | S460 |
| HE100A  | 0.41               | 0.54 | 0.58 | 0.57       | 0.68 | 0.72 | 0.13                 | 0.14 | 0.14 | 0.80                | 0.86 | 0.88 | 0.85      | 0.90 | 0.91 | 0.07                 | 0.08 | 0.08 |
| HE100B  | 0.40               | 0.53 | 0.57 | 0.56       | 0.67 | 0.71 | 0.13                 | 0.13 | 0.14 | 0.79                | 0.85 | 0.88 | 0.85      | 0.89 | 0.91 | 0.07                 | 0.08 | 0.08 |
| HE120A  | 0.30               | 0.42 | 0.46 | 0.46       | 0.58 | 0.63 | 0.11                 | 0.13 | 0.13 | 0.72                | 0.80 | 0.84 | 0.80      | 0.86 | 0.88 | 0.07                 | 0.07 | 0.08 |
| HE120B  | 0.29               | 0.41 | 0.44 | 0.44       | 0.57 | 0.61 | 0.11                 | 0.13 | 0.13 | 0.71                | 0.79 | 0.83 | 0.79      | 0.85 | 0.87 | 0.07                 | 0.07 | 0.08 |
| HE140A  | 0.23               | 0.33 | 0.34 | 0.36       | 0.49 | 0.53 | 0.10                 | 0.12 | 0.12 | 0.64                | 0.74 | 0.78 | 0.73      | 0.81 | 0.84 | 0.07                 | 0.07 | 0.07 |
| HE140B  | 0.22               | 0.31 | 0.32 | 0.34       | 0.47 | 0.51 | 0.10                 | 0.12 | 0.12 | 0.63                | 0.73 | 0.77 | 0.72      | 0.80 | 0.83 | 0.07                 | 0.07 | 0.07 |
| HE160A  | 0.18               | 0.26 | 0.26 | 0.29       | 0.41 | 0.43 | 0.09                 | 0.11 | 0.11 | 0.56                | 0.68 | 0.72 | 0.67      | 0.76 | 0.80 | 0.07                 | 0.07 | 0.07 |
| HE160B  | 0.17               | 0.25 | 0.24 | 0.27       | 0.39 | 0.41 | 0.09                 | 0.11 | 0.11 | 0.55                | 0.67 | 0.71 | 0.65      | 0.75 | 0.79 | 0.07                 | 0.07 | 0.07 |
| HE180A  | 0.14               | 0.21 | 0.19 | 0.23       | 0.33 | 0.35 | 0.08                 | 0.10 | 0.10 | 0.48                | 0.61 | 0.66 | 0.60      | 0.71 | 0.75 | 0.07                 | 0.07 | 0.07 |
| HE180B  | 0.13               | 0.20 | 0.18 | 0.22       | 0.32 | 0.33 | 0.07                 | 0.09 | 0.10 | 0.47                | 0.60 | 0.64 | 0.58      | 0.70 | 0.74 | 0.06                 | 0.07 | 0.07 |
| HE200A  | 0.12               | 0.17 | 0.15 | 0.19       | 0.27 | 0.28 | 0.07                 | 0.09 | 0.09 | 0.42                | 0.55 | 0.59 | 0.53      | 0.66 | 0.70 | 0.06                 | 0.07 | 0.07 |
| HE200B  | 0.11               | 0.16 | 0.14 | 0.18       | 0.26 | 0.26 | 0.06                 | 0.08 | 0.09 | 0.40                | 0.53 | 0.57 | 0.51      | 0.64 | 0.68 | 0.06                 | 0.07 | 0.07 |
| HE220A  | 0.10               | 0.14 | 0.12 | 0.16       | 0.23 | 0.22 | 0.06                 | 0.08 | 0.08 | 0.35                | 0.48 | 0.52 | 0.47      | 0.60 | 0.64 | 0.06                 | 0.07 | 0.07 |
| HE220B  | 0.09               | 0.13 | 0.12 | 0.15       | 0.22 | 0.21 | 0.05                 | 0.07 | 0.08 | 0.34                | 0.47 | 0.50 | 0.45      | 0.58 | 0.63 | 0.06                 | 0.06 | 0.07 |
| HE240A  | 0.08               | 0.12 | 0.10 | 0.13       | 0.19 | 0.18 | 0.05                 | 0.07 | 0.07 | 0.30                | 0.42 | 0.46 | 0.41      | 0.54 | 0.59 | 0.06                 | 0.06 | 0.07 |
| HE240B  | 0.08               | 0.11 | 0.10 | 0.13       | 0.18 | 0.17 | 0.05                 | 0.06 | 0.07 | 0.29                | 0.41 | 0.44 | 0.39      | 0.53 | 0.57 | 0.06                 | 0.06 | 0.07 |
| HE260A  | 0.07               | 0.10 | 0.09 | 0.11       | 0.16 | 0.15 | 0.04                 | 0.06 | 0.06 | 0.26                | 0.37 | 0.39 | 0.35      | 0.49 | 0.53 | 0.05                 | 0.06 | 0.06 |
| HE260B  | 0.06               | 0.10 | 0.08 | 0.11       | 0.16 | 0.14 | 0.04                 | 0.06 | 0.06 | 0.25                | 0.36 | 0.37 | 0.34      | 0.47 | 0.51 | 0.05                 | 0.06 | 0.06 |
| HE280A  | 0.06               | 0.09 |      | 0.10       | 0.14 |      | 0.04                 | 0.05 |      | 0.22                | 0.32 |      | 0.31      | 0.44 |      | 0.05                 | 0.06 |      |
| HE280B  | 0.05               | 0.08 | 0.07 | 0.09       | 0.14 | 0.12 | 0.03                 | 0.05 | 0.05 | 0.22                | 0.31 | 0.32 | 0.30      | 0.42 | 0.45 | 0.05                 | 0.06 | 0.06 |
| HE300A  | 0.05               | 0.07 | 0.06 | 0.08       | 0.12 | 0.11 | 0.03                 | 0.05 | 0.05 | 0.20                | 0.29 | 0.29 | 0.27      | 0.39 | 0.41 | 0.05                 | 0.06 | 0.06 |
| HE300B  | 0.04               | 0.07 | 0.06 | 0.08       | 0.12 | 0.10 | 0.03                 | 0.04 | 0.04 | 0.19                | 0.28 | 0.27 | 0.26      | 0.38 | 0.40 | 0.05                 | 0.05 | 0.06 |
| HE320A  | 0.04               | 0.06 | 0.05 | 0.07       | 0.11 | 0.09 | 0.03                 | 0.04 | 0.04 | 0.17                | 0.25 | 0.25 | 0.24      | 0.35 | 0.37 | 0.04                 | 0.05 | 0.06 |
| HE320B  | 0.04               | 0.06 | 0.05 | 0.07       | 0.11 | 0.09 | 0.03                 | 0.04 | 0.04 | 0.17                | 0.25 | 0.24 | 0.24      | 0.34 | 0.35 | 0.04                 | 0.05 | 0.06 |
| HE340A  | 0.03               | 0.06 | 0.05 | 0.06       | 0.10 | 0.08 | 0.02                 | 0.04 | 0.03 | 0.16                | 0.23 | 0.22 | 0.22      | 0.32 | 0.33 | 0.04                 | 0.05 | 0.05 |
| HE340B  | 0.03               | 0.05 | 0.05 | 0.06       | 0.10 | 0.08 | 0.02                 | 0.04 | 0.03 | 0.15                | 0.22 | 0.21 | 0.21      | 0.31 | 0.31 | 0.04                 | 0.05 | 0.05 |
| HE360A  | 0.03               | 0.05 | 0.04 | 0.06       | 0.09 | 0.07 | 0.02                 | 0.03 | 0.03 | 0.14                | 0.21 | 0.19 | 0.20      | 0.29 | 0.29 | 0.04                 | 0.05 | 0.05 |
| HE360B  | 0.03               | 0.05 | 0.04 | 0.05       | 0.09 | 0.07 | 0.02                 | 0.03 | 0.03 | 0.14                | 0.20 | 0.19 | 0.19      | 0.28 | 0.28 | 0.04                 | 0.05 | 0.05 |
| HE400A  | 0.01               | 0.02 | 0.02 | 0.03       | 0.05 | 0.04 | 0.01                 | 0.02 | 0.02 | 0.08                | 0.12 | 0.11 | 0.11      | 0.17 | 0.17 | 0.03                 | 0.04 | 0.04 |
| HE400B  | 0.01               | 0.02 | 0.02 | 0.03       | 0.04 | 0.04 | 0.01                 | 0.02 | 0.02 | 0.07                | 0.11 | 0.10 | 0.11      | 0.17 | 0.16 | 0.03                 | 0.04 | 0.04 |
| HE450A  | 0.01               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.01                 | 0.01 | 0.01 | 0.06                | 0.09 | 0.08 | 0.09      | 0.13 | 0.12 | 0.02                 | 0.03 | 0.04 |
| HE450B  | 0.00               | 0.02 | 0.01 | 0.02       | 0.03 | 0.03 | 0.01                 | 0.01 | 0.01 | 0.06                | 0.09 | 0.08 | 0.09      | 0.13 | 0.12 | 0.02                 | 0.03 | 0.04 |
| HE500A  | 0.00               | 0.01 |      | 0.01       | 0.03 |      | 0.01                 | 0.01 |      | 0.05                | 0.07 |      | 0.07      | 0.11 |      | 0.02                 | 0.03 |      |
| HE500B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.03 | 0.02 | 0.01                 | 0.01 | 0.01 | 0.05                | 0.07 | 0.06 | 0.07      | 0.11 | 0.09 | 0.02                 | 0.03 | 0.03 |



Table A1.16: Ratio  $M_{\text{splice}}/M_{\text{Rd}}$ ,  $L = 8 \text{ m}$ ,  $H_{\text{spl}} = 0.1L$ 

| Section | Fixed-fixed column |      |      |            |      |      | Pinned-pinned column |      |      | Fixed-guided column |      |      |           |      |      | Pinned-guided column |      |      |
|---------|--------------------|------|------|------------|------|------|----------------------|------|------|---------------------|------|------|-----------|------|------|----------------------|------|------|
|         | $K = 0.5$          |      |      | $K = 0.65$ |      |      | $K = 1.0$            |      |      | $K = 1.0$           |      |      | $K = 1.2$ |      |      | $K = 2.0$            |      |      |
|         | S235               | S355 | S460 | S235       | S355 | S460 | S235                 | S355 | S460 | S235                | S355 | S460 | S235      | S355 | S460 | S235                 | S355 | S460 |
| HE100A  | 0.35               | 0.46 | 0.50 | 0.49       | 0.58 | 0.61 | 0.25                 | 0.27 | 0.28 | 0.77                | 0.83 | 0.85 | 0.82      | 0.86 | 0.88 | 0.15                 | 0.15 | 0.15 |
| HE100B  | 0.34               | 0.45 | 0.48 | 0.48       | 0.57 | 0.60 | 0.25                 | 0.27 | 0.27 | 0.76                | 0.82 | 0.84 | 0.81      | 0.86 | 0.88 | 0.15                 | 0.15 | 0.15 |
| HE120A  | 0.26               | 0.36 | 0.39 | 0.39       | 0.50 | 0.53 | 0.23                 | 0.25 | 0.26 | 0.70                | 0.77 | 0.80 | 0.77      | 0.82 | 0.85 | 0.14                 | 0.15 | 0.15 |
| HE120B  | 0.25               | 0.35 | 0.37 | 0.38       | 0.48 | 0.52 | 0.22                 | 0.25 | 0.26 | 0.68                | 0.76 | 0.80 | 0.76      | 0.82 | 0.84 | 0.14                 | 0.15 | 0.15 |
| HE140A  | 0.19               | 0.28 | 0.29 | 0.31       | 0.42 | 0.45 | 0.20                 | 0.23 | 0.24 | 0.62                | 0.72 | 0.75 | 0.71      | 0.78 | 0.81 | 0.14                 | 0.15 | 0.15 |
| HE140B  | 0.18               | 0.27 | 0.27 | 0.29       | 0.40 | 0.43 | 0.20                 | 0.23 | 0.24 | 0.60                | 0.70 | 0.74 | 0.69      | 0.77 | 0.80 | 0.14                 | 0.15 | 0.15 |
| HE160A  | 0.15               | 0.22 | 0.22 | 0.24       | 0.34 | 0.37 | 0.18                 | 0.21 | 0.23 | 0.54                | 0.66 | 0.70 | 0.64      | 0.74 | 0.77 | 0.14                 | 0.14 | 0.15 |
| HE160B  | 0.14               | 0.21 | 0.20 | 0.23       | 0.33 | 0.35 | 0.17                 | 0.21 | 0.22 | 0.53                | 0.64 | 0.68 | 0.63      | 0.72 | 0.76 | 0.13                 | 0.14 | 0.14 |
| HE180A  | 0.12               | 0.18 | 0.17 | 0.20       | 0.28 | 0.29 | 0.15                 | 0.19 | 0.21 | 0.47                | 0.59 | 0.63 | 0.58      | 0.68 | 0.72 | 0.13                 | 0.14 | 0.14 |
| HE180B  | 0.11               | 0.17 | 0.16 | 0.19       | 0.27 | 0.28 | 0.15                 | 0.19 | 0.20 | 0.45                | 0.57 | 0.62 | 0.56      | 0.67 | 0.71 | 0.13                 | 0.14 | 0.14 |
| HE200A  | 0.10               | 0.15 | 0.13 | 0.16       | 0.23 | 0.23 | 0.13                 | 0.17 | 0.19 | 0.40                | 0.53 | 0.57 | 0.51      | 0.63 | 0.67 | 0.13                 | 0.14 | 0.14 |
| HE200B  | 0.09               | 0.14 | 0.12 | 0.15       | 0.22 | 0.22 | 0.12                 | 0.17 | 0.18 | 0.38                | 0.51 | 0.55 | 0.49      | 0.62 | 0.66 | 0.12                 | 0.13 | 0.14 |
| HE220A  | 0.08               | 0.12 | 0.11 | 0.13       | 0.19 | 0.19 | 0.11                 | 0.15 | 0.16 | 0.34                | 0.47 | 0.50 | 0.45      | 0.58 | 0.62 | 0.12                 | 0.13 | 0.14 |
| HE220B  | 0.08               | 0.11 | 0.10 | 0.13       | 0.19 | 0.18 | 0.11                 | 0.15 | 0.16 | 0.32                | 0.45 | 0.48 | 0.43      | 0.56 | 0.60 | 0.12                 | 0.13 | 0.13 |
| HE240A  | 0.07               | 0.10 | 0.09 | 0.11       | 0.16 | 0.15 | 0.09                 | 0.13 | 0.14 | 0.29                | 0.41 | 0.44 | 0.39      | 0.52 | 0.56 | 0.11                 | 0.13 | 0.13 |
| HE240B  | 0.06               | 0.10 | 0.08 | 0.11       | 0.16 | 0.14 | 0.09                 | 0.13 | 0.14 | 0.28                | 0.39 | 0.42 | 0.38      | 0.51 | 0.55 | 0.11                 | 0.12 | 0.13 |
| HE260A  | 0.06               | 0.09 | 0.07 | 0.10       | 0.14 | 0.13 | 0.08                 | 0.12 | 0.12 | 0.25                | 0.36 | 0.38 | 0.34      | 0.47 | 0.51 | 0.11                 | 0.12 | 0.13 |
| HE260B  | 0.05               | 0.08 | 0.07 | 0.09       | 0.13 | 0.12 | 0.08                 | 0.11 | 0.12 | 0.24                | 0.34 | 0.36 | 0.33      | 0.45 | 0.49 | 0.10                 | 0.12 | 0.13 |
| HE280A  | 0.05               | 0.07 |      | 0.08       | 0.12 |      | 0.07                 | 0.10 |      | 0.22                | 0.31 |      | 0.30      | 0.42 |      | 0.10                 | 0.12 |      |
| HE280B  | 0.04               | 0.07 | 0.06 | 0.08       | 0.12 | 0.10 | 0.07                 | 0.10 | 0.10 | 0.21                | 0.30 | 0.31 | 0.29      | 0.41 | 0.44 | 0.10                 | 0.11 | 0.12 |
| HE300A  | 0.04               | 0.06 | 0.05 | 0.07       | 0.11 | 0.09 | 0.06                 | 0.09 | 0.09 | 0.19                | 0.27 | 0.28 | 0.26      | 0.37 | 0.40 | 0.09                 | 0.11 | 0.12 |
| HE300B  | 0.04               | 0.06 | 0.05 | 0.07       | 0.10 | 0.09 | 0.06                 | 0.09 | 0.09 | 0.18                | 0.27 | 0.26 | 0.25      | 0.36 | 0.38 | 0.09                 | 0.11 | 0.12 |
| HE320A  | 0.03               | 0.06 | 0.05 | 0.06       | 0.09 | 0.08 | 0.05                 | 0.08 | 0.08 | 0.17                | 0.25 | 0.24 | 0.23      | 0.34 | 0.35 | 0.09                 | 0.11 | 0.11 |
| HE320B  | 0.03               | 0.05 | 0.04 | 0.06       | 0.09 | 0.08 | 0.05                 | 0.08 | 0.07 | 0.16                | 0.24 | 0.23 | 0.23      | 0.33 | 0.34 | 0.08                 | 0.10 | 0.11 |
| HE340A  | 0.03               | 0.05 | 0.04 | 0.05       | 0.08 | 0.07 | 0.05                 | 0.07 | 0.07 | 0.15                | 0.22 | 0.21 | 0.21      | 0.31 | 0.31 | 0.08                 | 0.10 | 0.11 |
| HE340B  | 0.03               | 0.05 | 0.04 | 0.05       | 0.08 | 0.07 | 0.05                 | 0.07 | 0.07 | 0.15                | 0.21 | 0.20 | 0.20      | 0.30 | 0.30 | 0.08                 | 0.10 | 0.11 |
| HE360A  | 0.02               | 0.04 | 0.04 | 0.05       | 0.08 | 0.06 | 0.04                 | 0.06 | 0.06 | 0.14                | 0.20 | 0.19 | 0.19      | 0.28 | 0.28 | 0.07                 | 0.10 | 0.10 |
| HE360B  | 0.02               | 0.04 | 0.04 | 0.05       | 0.07 | 0.06 | 0.04                 | 0.06 | 0.06 | 0.13                | 0.19 | 0.18 | 0.19      | 0.27 | 0.27 | 0.07                 | 0.09 | 0.10 |
| HE400A  | 0.01               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.02                 | 0.04 | 0.03 | 0.07                | 0.11 | 0.10 | 0.11      | 0.17 | 0.16 | 0.05                 | 0.08 | 0.09 |
| HE400B  | 0.01               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.02                 | 0.04 | 0.03 | 0.07                | 0.11 | 0.10 | 0.10      | 0.16 | 0.16 | 0.05                 | 0.08 | 0.09 |
| HE450A  | 0.00               | 0.01 | 0.01 | 0.02       | 0.03 | 0.03 | 0.02                 | 0.03 | 0.02 | 0.06                | 0.09 | 0.08 | 0.08      | 0.13 | 0.12 | 0.04                 | 0.06 | 0.07 |
| HE450B  | 0.00               | 0.01 | 0.01 | 0.02       | 0.03 | 0.02 | 0.02                 | 0.03 | 0.02 | 0.06                | 0.09 | 0.07 | 0.08      | 0.13 | 0.12 | 0.04                 | 0.06 | 0.07 |
| HE500A  | 0.00               | 0.01 |      | 0.01       | 0.02 |      | 0.02                 | 0.02 |      | 0.05                | 0.07 |      | 0.07      | 0.10 |      | 0.03                 | 0.05 |      |
| HE500B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.01                 | 0.02 | 0.02 | 0.05                | 0.07 | 0.06 | 0.07      | 0.10 | 0.09 | 0.03                 | 0.05 | 0.06 |

**Table A1.17:** Ratio  $M_{\text{splice}}/M_{\text{Rd}}$ ,  $L = 8 \text{ m}$ ,  $H_{\text{spl}} = 0.2L$

| Section | Fixed-fixed column |      |      |            |      |      | Pinned-pinned column |      |      | Fixed-guided column |      |      |           |      |      | Pinned-guided column |      |      |
|---------|--------------------|------|------|------------|------|------|----------------------|------|------|---------------------|------|------|-----------|------|------|----------------------|------|------|
|         | $K = 0.5$          |      |      | $K = 0.65$ |      |      | $K = 1.0$            |      |      | $K = 1.0$           |      |      | $K = 1.2$ |      |      | $K = 2.0$            |      |      |
|         | S235               | S355 | S460 | S235       | S355 | S460 | S235                 | S355 | S460 | S235                | S355 | S460 | S235      | S355 | S460 | S235                 | S355 | S460 |
| HE100A  | 0.13               | 0.18 | 0.19 | 0.19       | 0.22 | 0.23 | 0.47                 | 0.51 | 0.52 | 0.65                | 0.70 | 0.72 | 0.70      | 0.73 | 0.75 | 0.29                 | 0.30 | 0.30 |
| HE100B  | 0.13               | 0.17 | 0.18 | 0.18       | 0.22 | 0.23 | 0.47                 | 0.51 | 0.52 | 0.65                | 0.70 | 0.72 | 0.69      | 0.73 | 0.74 | 0.29                 | 0.30 | 0.30 |
| HE120A  | 0.10               | 0.14 | 0.15 | 0.15       | 0.19 | 0.20 | 0.43                 | 0.48 | 0.50 | 0.59                | 0.66 | 0.68 | 0.65      | 0.70 | 0.72 | 0.29                 | 0.29 | 0.30 |
| HE120B  | 0.09               | 0.13 | 0.14 | 0.14       | 0.18 | 0.20 | 0.42                 | 0.47 | 0.49 | 0.58                | 0.65 | 0.68 | 0.64      | 0.70 | 0.72 | 0.28                 | 0.29 | 0.30 |
| HE140A  | 0.07               | 0.11 | 0.11 | 0.12       | 0.16 | 0.17 | 0.38                 | 0.44 | 0.47 | 0.53                | 0.61 | 0.64 | 0.60      | 0.67 | 0.69 | 0.28                 | 0.29 | 0.29 |
| HE140B  | 0.07               | 0.10 | 0.10 | 0.11       | 0.15 | 0.17 | 0.37                 | 0.43 | 0.46 | 0.51                | 0.60 | 0.63 | 0.59      | 0.66 | 0.68 | 0.28                 | 0.29 | 0.29 |
| HE160A  | 0.06               | 0.08 | 0.08 | 0.09       | 0.13 | 0.14 | 0.34                 | 0.41 | 0.43 | 0.46                | 0.56 | 0.59 | 0.55      | 0.63 | 0.66 | 0.27                 | 0.28 | 0.29 |
| HE160B  | 0.05               | 0.08 | 0.08 | 0.09       | 0.13 | 0.13 | 0.32                 | 0.40 | 0.42 | 0.45                | 0.55 | 0.58 | 0.53      | 0.62 | 0.65 | 0.27                 | 0.28 | 0.29 |
| HE180A  | 0.05               | 0.07 | 0.06 | 0.07       | 0.11 | 0.11 | 0.29                 | 0.37 | 0.39 | 0.40                | 0.50 | 0.54 | 0.49      | 0.58 | 0.61 | 0.26                 | 0.27 | 0.28 |
| HE180B  | 0.04               | 0.06 | 0.06 | 0.07       | 0.10 | 0.11 | 0.28                 | 0.36 | 0.38 | 0.38                | 0.49 | 0.53 | 0.48      | 0.57 | 0.60 | 0.26                 | 0.27 | 0.28 |
| HE200A  | 0.04               | 0.06 | 0.05 | 0.06       | 0.09 | 0.09 | 0.25                 | 0.33 | 0.35 | 0.34                | 0.45 | 0.49 | 0.44      | 0.54 | 0.57 | 0.25                 | 0.27 | 0.27 |
| HE200B  | 0.04               | 0.05 | 0.05 | 0.06       | 0.08 | 0.08 | 0.24                 | 0.31 | 0.34 | 0.32                | 0.43 | 0.47 | 0.42      | 0.52 | 0.56 | 0.24                 | 0.26 | 0.27 |
| HE220A  | 0.03               | 0.05 | 0.04 | 0.05       | 0.07 | 0.07 | 0.21                 | 0.29 | 0.31 | 0.29                | 0.40 | 0.43 | 0.38      | 0.49 | 0.53 | 0.24                 | 0.26 | 0.27 |
| HE220B  | 0.03               | 0.04 | 0.04 | 0.05       | 0.07 | 0.07 | 0.20                 | 0.28 | 0.30 | 0.28                | 0.38 | 0.41 | 0.37      | 0.48 | 0.51 | 0.23                 | 0.26 | 0.26 |
| HE240A  | 0.03               | 0.04 | 0.03 | 0.04       | 0.06 | 0.06 | 0.18                 | 0.25 | 0.27 | 0.25                | 0.35 | 0.37 | 0.33      | 0.44 | 0.48 | 0.22                 | 0.25 | 0.26 |
| HE240B  | 0.02               | 0.04 | 0.03 | 0.04       | 0.06 | 0.05 | 0.17                 | 0.24 | 0.26 | 0.24                | 0.33 | 0.36 | 0.32      | 0.43 | 0.47 | 0.22                 | 0.25 | 0.26 |
| HE260A  | 0.02               | 0.03 | 0.03 | 0.04       | 0.05 | 0.05 | 0.15                 | 0.22 | 0.23 | 0.21                | 0.30 | 0.32 | 0.29      | 0.40 | 0.43 | 0.21                 | 0.24 | 0.25 |
| HE260B  | 0.02               | 0.03 | 0.03 | 0.03       | 0.05 | 0.05 | 0.15                 | 0.21 | 0.22 | 0.20                | 0.29 | 0.31 | 0.28      | 0.39 | 0.42 | 0.21                 | 0.24 | 0.25 |
| HE280A  | 0.02               | 0.03 |      | 0.03       | 0.05 |      | 0.13                 | 0.19 |      | 0.18                | 0.27 |      | 0.25      | 0.36 |      | 0.20                 | 0.23 |      |
| HE280B  | 0.02               | 0.03 | 0.02 | 0.03       | 0.04 | 0.04 | 0.13                 | 0.19 | 0.19 | 0.18                | 0.26 | 0.26 | 0.25      | 0.35 | 0.37 | 0.19                 | 0.23 | 0.24 |
| HE300A  | 0.02               | 0.02 | 0.02 | 0.03       | 0.04 | 0.03 | 0.12                 | 0.17 | 0.17 | 0.16                | 0.23 | 0.23 | 0.22      | 0.32 | 0.34 | 0.18                 | 0.22 | 0.23 |
| HE300B  | 0.01               | 0.02 | 0.02 | 0.03       | 0.04 | 0.03 | 0.11                 | 0.16 | 0.16 | 0.16                | 0.23 | 0.22 | 0.22      | 0.31 | 0.33 | 0.18                 | 0.22 | 0.23 |
| HE320A  | 0.01               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.10                 | 0.15 | 0.15 | 0.14                | 0.21 | 0.20 | 0.20      | 0.29 | 0.30 | 0.17                 | 0.21 | 0.22 |
| HE320B  | 0.01               | 0.02 | 0.02 | 0.02       | 0.03 | 0.03 | 0.10                 | 0.15 | 0.14 | 0.14                | 0.20 | 0.20 | 0.19      | 0.28 | 0.29 | 0.17                 | 0.20 | 0.22 |
| HE340A  | 0.01               | 0.02 | 0.02 | 0.02       | 0.03 | 0.03 | 0.09                 | 0.14 | 0.13 | 0.13                | 0.19 | 0.18 | 0.18      | 0.26 | 0.27 | 0.16                 | 0.20 | 0.21 |
| HE340B  | 0.01               | 0.02 | 0.02 | 0.02       | 0.03 | 0.03 | 0.09                 | 0.13 | 0.12 | 0.12                | 0.18 | 0.17 | 0.17      | 0.25 | 0.26 | 0.15                 | 0.19 | 0.21 |
| HE360A  | 0.01               | 0.02 | 0.01 | 0.02       | 0.03 | 0.02 | 0.08                 | 0.12 | 0.11 | 0.12                | 0.17 | 0.16 | 0.16      | 0.24 | 0.24 | 0.15                 | 0.19 | 0.20 |
| HE360B  | 0.01               | 0.02 | 0.01 | 0.02       | 0.03 | 0.02 | 0.08                 | 0.12 | 0.11 | 0.11                | 0.16 | 0.15 | 0.16      | 0.23 | 0.23 | 0.14                 | 0.18 | 0.20 |
| HE400A  | 0.00               | 0.01 | 0.01 | 0.01       | 0.01 | 0.01 | 0.05                 | 0.07 | 0.06 | 0.06                | 0.10 | 0.09 | 0.09      | 0.14 | 0.14 | 0.11                 | 0.15 | 0.17 |
| HE400B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.01 | 0.01 | 0.04                 | 0.07 | 0.06 | 0.06                | 0.09 | 0.08 | 0.09      | 0.14 | 0.13 | 0.10                 | 0.15 | 0.17 |
| HE450A  | 0.00               | 0.01 | 0.01 | 0.01       | 0.01 | 0.01 | 0.04                 | 0.05 | 0.05 | 0.05                | 0.08 | 0.07 | 0.07      | 0.11 | 0.10 | 0.08                 | 0.13 | 0.14 |
| HE450B  | 0.00               | 0.01 | 0.00 | 0.01       | 0.01 | 0.01 | 0.03                 | 0.05 | 0.05 | 0.05                | 0.07 | 0.06 | 0.07      | 0.11 | 0.10 | 0.08                 | 0.12 | 0.14 |
| HE500A  | 0.00               | 0.00 |      | 0.00       | 0.01 |      | 0.03                 | 0.04 |      | 0.04                | 0.06 |      | 0.06      | 0.09 |      | 0.07                 | 0.10 |      |
| HE500B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.04 | 0.04 | 0.04                | 0.06 | 0.05 | 0.06      | 0.09 | 0.08 | 0.06                 | 0.10 | 0.11 |



Table A1.18: Ratio  $M_{\text{splice}}/M_{\text{Rd}}$ ,  $L = 8 \text{ m}$ ,  $H_{\text{spl}} = 0.4L$ 

| Section | Fixed-fixed column |      |      |            |      |      | Pinned-pinned column |      |      | Fixed-guided column |      |      |           |      |      | Pinned-guided column |      |      |
|---------|--------------------|------|------|------------|------|------|----------------------|------|------|---------------------|------|------|-----------|------|------|----------------------|------|------|
|         | $K = 0.5$          |      |      | $K = 0.65$ |      |      | $K = 1.0$            |      |      | $K = 1.0$           |      |      | $K = 1.2$ |      |      | $K = 2.0$            |      |      |
|         | S235               | S355 | S460 | S235       | S355 | S460 | S235                 | S355 | S460 | S235                | S355 | S460 | S235      | S355 | S460 | S235                 | S355 | S460 |
| HE100A  | 0.35               | 0.46 | 0.50 | 0.49       | 0.58 | 0.61 | 0.77                 | 0.83 | 0.85 | 0.25                | 0.27 | 0.28 | 0.27      | 0.28 | 0.29 | 0.56                 | 0.57 | 0.57 |
| HE100B  | 0.34               | 0.45 | 0.48 | 0.48       | 0.57 | 0.60 | 0.76                 | 0.82 | 0.84 | 0.25                | 0.27 | 0.27 | 0.26      | 0.28 | 0.28 | 0.56                 | 0.57 | 0.57 |
| HE120A  | 0.26               | 0.36 | 0.39 | 0.39       | 0.50 | 0.53 | 0.70                 | 0.77 | 0.80 | 0.23                | 0.25 | 0.26 | 0.25      | 0.27 | 0.28 | 0.54                 | 0.56 | 0.56 |
| HE120B  | 0.25               | 0.35 | 0.37 | 0.38       | 0.48 | 0.52 | 0.68                 | 0.76 | 0.80 | 0.22                | 0.25 | 0.26 | 0.25      | 0.27 | 0.27 | 0.54                 | 0.56 | 0.56 |
| HE140A  | 0.19               | 0.28 | 0.29 | 0.31       | 0.42 | 0.45 | 0.62                 | 0.72 | 0.75 | 0.20                | 0.23 | 0.24 | 0.23      | 0.25 | 0.26 | 0.53                 | 0.55 | 0.56 |
| HE140B  | 0.18               | 0.27 | 0.27 | 0.29       | 0.40 | 0.43 | 0.60                 | 0.70 | 0.74 | 0.20                | 0.23 | 0.24 | 0.23      | 0.25 | 0.26 | 0.52                 | 0.54 | 0.55 |
| HE160A  | 0.15               | 0.22 | 0.22 | 0.24       | 0.34 | 0.37 | 0.54                 | 0.66 | 0.70 | 0.18                | 0.21 | 0.23 | 0.21      | 0.24 | 0.25 | 0.51                 | 0.54 | 0.55 |
| HE160B  | 0.14               | 0.21 | 0.20 | 0.23       | 0.33 | 0.35 | 0.53                 | 0.64 | 0.68 | 0.17                | 0.21 | 0.22 | 0.20      | 0.24 | 0.25 | 0.51                 | 0.53 | 0.54 |
| HE180A  | 0.12               | 0.18 | 0.17 | 0.20       | 0.28 | 0.29 | 0.47                 | 0.59 | 0.63 | 0.15                | 0.19 | 0.21 | 0.19      | 0.22 | 0.23 | 0.49                 | 0.52 | 0.53 |
| HE180B  | 0.11               | 0.17 | 0.16 | 0.19       | 0.27 | 0.28 | 0.45                 | 0.57 | 0.62 | 0.15                | 0.19 | 0.20 | 0.18      | 0.22 | 0.23 | 0.49                 | 0.52 | 0.53 |
| HE200A  | 0.10               | 0.15 | 0.13 | 0.16       | 0.23 | 0.23 | 0.40                 | 0.53 | 0.57 | 0.13                | 0.17 | 0.19 | 0.17      | 0.21 | 0.22 | 0.47                 | 0.51 | 0.52 |
| HE200B  | 0.09               | 0.14 | 0.12 | 0.15       | 0.22 | 0.22 | 0.38                 | 0.51 | 0.55 | 0.12                | 0.17 | 0.18 | 0.16      | 0.20 | 0.21 | 0.46                 | 0.50 | 0.52 |
| HE220A  | 0.08               | 0.12 | 0.11 | 0.13       | 0.19 | 0.19 | 0.34                 | 0.47 | 0.50 | 0.11                | 0.15 | 0.16 | 0.15      | 0.19 | 0.20 | 0.45                 | 0.49 | 0.51 |
| HE220B  | 0.08               | 0.11 | 0.10 | 0.13       | 0.19 | 0.18 | 0.32                 | 0.45 | 0.48 | 0.11                | 0.15 | 0.16 | 0.14      | 0.18 | 0.20 | 0.44                 | 0.49 | 0.50 |
| HE240A  | 0.07               | 0.10 | 0.09 | 0.11       | 0.16 | 0.15 | 0.29                 | 0.41 | 0.44 | 0.09                | 0.13 | 0.14 | 0.13      | 0.17 | 0.18 | 0.42                 | 0.47 | 0.49 |
| HE240B  | 0.06               | 0.10 | 0.08 | 0.11       | 0.16 | 0.14 | 0.28                 | 0.39 | 0.42 | 0.09                | 0.13 | 0.14 | 0.12      | 0.16 | 0.18 | 0.42                 | 0.47 | 0.49 |
| HE260A  | 0.06               | 0.09 | 0.07 | 0.10       | 0.14 | 0.13 | 0.25                 | 0.36 | 0.38 | 0.08                | 0.12 | 0.12 | 0.11      | 0.15 | 0.16 | 0.40                 | 0.45 | 0.48 |
| HE260B  | 0.05               | 0.08 | 0.07 | 0.09       | 0.13 | 0.12 | 0.24                 | 0.34 | 0.36 | 0.08                | 0.11 | 0.12 | 0.11      | 0.15 | 0.16 | 0.39                 | 0.45 | 0.47 |
| HE280A  | 0.05               | 0.07 |      | 0.08       | 0.12 |      | 0.22                 | 0.31 |      | 0.07                | 0.10 |      | 0.10      | 0.14 |      | 0.37                 | 0.43 |      |
| HE280B  | 0.04               | 0.07 | 0.06 | 0.08       | 0.12 | 0.10 | 0.21                 | 0.30 | 0.31 | 0.07                | 0.10 | 0.10 | 0.09      | 0.13 | 0.14 | 0.37                 | 0.43 | 0.45 |
| HE300A  | 0.04               | 0.06 | 0.05 | 0.07       | 0.11 | 0.09 | 0.19                 | 0.27 | 0.28 | 0.06                | 0.09 | 0.09 | 0.09      | 0.12 | 0.13 | 0.35                 | 0.41 | 0.44 |
| HE300B  | 0.04               | 0.06 | 0.05 | 0.07       | 0.10 | 0.09 | 0.18                 | 0.27 | 0.26 | 0.06                | 0.09 | 0.09 | 0.08      | 0.12 | 0.12 | 0.34                 | 0.41 | 0.43 |
| HE320A  | 0.03               | 0.06 | 0.05 | 0.06       | 0.09 | 0.08 | 0.17                 | 0.25 | 0.24 | 0.05                | 0.08 | 0.08 | 0.08      | 0.11 | 0.11 | 0.32                 | 0.40 | 0.42 |
| HE320B  | 0.03               | 0.05 | 0.04 | 0.06       | 0.09 | 0.08 | 0.16                 | 0.24 | 0.23 | 0.05                | 0.08 | 0.07 | 0.07      | 0.11 | 0.11 | 0.32                 | 0.39 | 0.42 |
| HE340A  | 0.03               | 0.05 | 0.04 | 0.05       | 0.08 | 0.07 | 0.15                 | 0.22 | 0.21 | 0.05                | 0.07 | 0.07 | 0.07      | 0.10 | 0.10 | 0.30                 | 0.38 | 0.40 |
| HE340B  | 0.03               | 0.05 | 0.04 | 0.05       | 0.08 | 0.07 | 0.15                 | 0.21 | 0.20 | 0.05                | 0.07 | 0.07 | 0.07      | 0.10 | 0.10 | 0.29                 | 0.37 | 0.40 |
| HE360A  | 0.02               | 0.04 | 0.04 | 0.05       | 0.08 | 0.06 | 0.14                 | 0.20 | 0.19 | 0.04                | 0.06 | 0.06 | 0.06      | 0.09 | 0.09 | 0.28                 | 0.36 | 0.38 |
| HE360B  | 0.02               | 0.04 | 0.04 | 0.05       | 0.07 | 0.06 | 0.13                 | 0.19 | 0.18 | 0.04                | 0.06 | 0.06 | 0.06      | 0.09 | 0.09 | 0.27                 | 0.35 | 0.38 |
| HE400A  | 0.01               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.07                 | 0.11 | 0.10 | 0.02                | 0.04 | 0.03 | 0.03      | 0.05 | 0.05 | 0.20                 | 0.29 | 0.33 |
| HE400B  | 0.01               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.07                 | 0.11 | 0.10 | 0.02                | 0.04 | 0.03 | 0.03      | 0.05 | 0.05 | 0.20                 | 0.29 | 0.32 |
| HE450A  | 0.00               | 0.01 | 0.01 | 0.02       | 0.03 | 0.03 | 0.06                 | 0.09 | 0.08 | 0.02                | 0.03 | 0.02 | 0.03      | 0.04 | 0.04 | 0.16                 | 0.24 | 0.28 |
| HE450B  | 0.00               | 0.01 | 0.01 | 0.02       | 0.03 | 0.02 | 0.06                 | 0.09 | 0.07 | 0.02                | 0.03 | 0.02 | 0.03      | 0.04 | 0.04 | 0.15                 | 0.23 | 0.27 |
| HE500A  | 0.00               | 0.01 |      | 0.01       | 0.02 |      | 0.05                 | 0.07 |      | 0.02                | 0.02 |      | 0.02      | 0.03 |      | 0.12                 | 0.20 |      |
| HE500B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.05                 | 0.07 | 0.06 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.03 | 0.12                 | 0.19 | 0.22 |



**Table A1.19:** Ratio  $M_{\text{splice}}/M_{\text{Rd}}$ ,  $L = 8 \text{ m}$ ,  $H_{\text{spl}} = 0.6L$

| Section | Fixed-fixed column |      |      |            |      |      | Pinned-pinned column |      |      | Fixed-guided column |      |      |           |      |      | Pinned-guided column |      |      |
|---------|--------------------|------|------|------------|------|------|----------------------|------|------|---------------------|------|------|-----------|------|------|----------------------|------|------|
|         | $K = 0.5$          |      |      | $K = 0.65$ |      |      | $K = 1.0$            |      |      | $K = 1.0$           |      |      | $K = 1.2$ |      |      | $K = 2.0$            |      |      |
|         | S235               | S355 | S460 | S235       | S355 | S460 | S235                 | S355 | S460 | S235                | S355 | S460 | S235      | S355 | S460 | S235                 | S355 | S460 |
| HE100A  | 0.35               | 0.46 | 0.50 | 0.49       | 0.58 | 0.61 | 0.77                 | 0.83 | 0.85 | 0.25                | 0.27 | 0.28 | 0.27      | 0.28 | 0.29 | 0.77                 | 0.78 | 0.79 |
| HE100B  | 0.34               | 0.45 | 0.48 | 0.48       | 0.57 | 0.60 | 0.76                 | 0.82 | 0.84 | 0.25                | 0.27 | 0.27 | 0.26      | 0.28 | 0.28 | 0.76                 | 0.78 | 0.79 |
| HE120A  | 0.26               | 0.36 | 0.39 | 0.39       | 0.50 | 0.53 | 0.70                 | 0.77 | 0.80 | 0.23                | 0.25 | 0.26 | 0.25      | 0.27 | 0.28 | 0.75                 | 0.77 | 0.78 |
| HE120B  | 0.25               | 0.35 | 0.37 | 0.38       | 0.48 | 0.52 | 0.68                 | 0.76 | 0.80 | 0.22                | 0.25 | 0.26 | 0.25      | 0.27 | 0.27 | 0.74                 | 0.77 | 0.77 |
| HE140A  | 0.19               | 0.28 | 0.29 | 0.31       | 0.42 | 0.45 | 0.62                 | 0.72 | 0.75 | 0.20                | 0.23 | 0.24 | 0.23      | 0.25 | 0.26 | 0.73                 | 0.75 | 0.76 |
| HE140B  | 0.18               | 0.27 | 0.27 | 0.29       | 0.40 | 0.43 | 0.60                 | 0.70 | 0.74 | 0.20                | 0.23 | 0.24 | 0.23      | 0.25 | 0.26 | 0.72                 | 0.75 | 0.76 |
| HE160A  | 0.15               | 0.22 | 0.22 | 0.24       | 0.34 | 0.37 | 0.54                 | 0.66 | 0.70 | 0.18                | 0.21 | 0.23 | 0.21      | 0.24 | 0.25 | 0.70                 | 0.74 | 0.75 |
| HE160B  | 0.14               | 0.21 | 0.20 | 0.23       | 0.33 | 0.35 | 0.53                 | 0.64 | 0.68 | 0.17                | 0.21 | 0.22 | 0.20      | 0.24 | 0.25 | 0.70                 | 0.73 | 0.75 |
| HE180A  | 0.12               | 0.18 | 0.17 | 0.20       | 0.28 | 0.29 | 0.47                 | 0.59 | 0.63 | 0.15                | 0.19 | 0.21 | 0.19      | 0.22 | 0.23 | 0.68                 | 0.72 | 0.74 |
| HE180B  | 0.11               | 0.17 | 0.16 | 0.19       | 0.27 | 0.28 | 0.45                 | 0.57 | 0.62 | 0.15                | 0.19 | 0.20 | 0.18      | 0.22 | 0.23 | 0.67                 | 0.71 | 0.73 |
| HE200A  | 0.10               | 0.15 | 0.13 | 0.16       | 0.23 | 0.23 | 0.40                 | 0.53 | 0.57 | 0.13                | 0.17 | 0.19 | 0.17      | 0.21 | 0.22 | 0.65                 | 0.70 | 0.72 |
| HE200B  | 0.09               | 0.14 | 0.12 | 0.15       | 0.22 | 0.22 | 0.38                 | 0.51 | 0.55 | 0.12                | 0.17 | 0.18 | 0.16      | 0.20 | 0.21 | 0.64                 | 0.69 | 0.71 |
| HE220A  | 0.08               | 0.12 | 0.11 | 0.13       | 0.19 | 0.19 | 0.34                 | 0.47 | 0.50 | 0.11                | 0.15 | 0.16 | 0.15      | 0.19 | 0.20 | 0.62                 | 0.68 | 0.70 |
| HE220B  | 0.08               | 0.11 | 0.10 | 0.13       | 0.19 | 0.18 | 0.32                 | 0.45 | 0.48 | 0.11                | 0.15 | 0.16 | 0.14      | 0.18 | 0.20 | 0.61                 | 0.67 | 0.69 |
| HE240A  | 0.07               | 0.10 | 0.09 | 0.11       | 0.16 | 0.15 | 0.29                 | 0.41 | 0.44 | 0.09                | 0.13 | 0.14 | 0.13      | 0.17 | 0.18 | 0.58                 | 0.65 | 0.68 |
| HE240B  | 0.06               | 0.10 | 0.08 | 0.11       | 0.16 | 0.14 | 0.28                 | 0.39 | 0.42 | 0.09                | 0.13 | 0.14 | 0.12      | 0.16 | 0.18 | 0.57                 | 0.64 | 0.67 |
| HE260A  | 0.06               | 0.09 | 0.07 | 0.10       | 0.14 | 0.13 | 0.25                 | 0.36 | 0.38 | 0.08                | 0.12 | 0.12 | 0.11      | 0.15 | 0.16 | 0.55                 | 0.62 | 0.65 |
| HE260B  | 0.05               | 0.08 | 0.07 | 0.09       | 0.13 | 0.12 | 0.24                 | 0.34 | 0.36 | 0.08                | 0.11 | 0.12 | 0.11      | 0.15 | 0.16 | 0.54                 | 0.62 | 0.65 |
| HE280A  | 0.05               | 0.07 |      | 0.08       | 0.12 |      | 0.22                 | 0.31 |      | 0.07                | 0.10 |      | 0.10      | 0.14 |      | 0.51                 | 0.60 |      |
| HE280B  | 0.04               | 0.07 | 0.06 | 0.08       | 0.12 | 0.10 | 0.21                 | 0.30 | 0.31 | 0.07                | 0.10 | 0.10 | 0.09      | 0.13 | 0.14 | 0.50                 | 0.59 | 0.62 |
| HE300A  | 0.04               | 0.06 | 0.05 | 0.07       | 0.11 | 0.09 | 0.19                 | 0.27 | 0.28 | 0.06                | 0.09 | 0.09 | 0.09      | 0.12 | 0.13 | 0.48                 | 0.57 | 0.61 |
| HE300B  | 0.04               | 0.06 | 0.05 | 0.07       | 0.10 | 0.09 | 0.18                 | 0.27 | 0.26 | 0.06                | 0.09 | 0.09 | 0.08      | 0.12 | 0.12 | 0.47                 | 0.56 | 0.60 |
| HE320A  | 0.03               | 0.06 | 0.05 | 0.06       | 0.09 | 0.08 | 0.17                 | 0.25 | 0.24 | 0.05                | 0.08 | 0.08 | 0.08      | 0.11 | 0.11 | 0.45                 | 0.54 | 0.58 |
| HE320B  | 0.03               | 0.05 | 0.04 | 0.06       | 0.09 | 0.08 | 0.16                 | 0.24 | 0.23 | 0.05                | 0.08 | 0.07 | 0.07      | 0.11 | 0.11 | 0.44                 | 0.54 | 0.57 |
| HE340A  | 0.03               | 0.05 | 0.04 | 0.05       | 0.08 | 0.07 | 0.15                 | 0.22 | 0.21 | 0.05                | 0.07 | 0.07 | 0.07      | 0.10 | 0.10 | 0.41                 | 0.52 | 0.55 |
| HE340B  | 0.03               | 0.05 | 0.04 | 0.05       | 0.08 | 0.07 | 0.15                 | 0.21 | 0.20 | 0.05                | 0.07 | 0.07 | 0.07      | 0.10 | 0.10 | 0.41                 | 0.51 | 0.55 |
| HE360A  | 0.02               | 0.04 | 0.04 | 0.05       | 0.08 | 0.06 | 0.14                 | 0.20 | 0.19 | 0.04                | 0.06 | 0.06 | 0.06      | 0.09 | 0.09 | 0.39                 | 0.49 | 0.53 |
| HE360B  | 0.02               | 0.04 | 0.04 | 0.05       | 0.07 | 0.06 | 0.13                 | 0.19 | 0.18 | 0.04                | 0.06 | 0.06 | 0.06      | 0.09 | 0.09 | 0.38                 | 0.48 | 0.52 |
| HE400A  | 0.01               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.07                 | 0.11 | 0.10 | 0.02                | 0.04 | 0.03 | 0.03      | 0.05 | 0.05 | 0.28                 | 0.40 | 0.46 |
| HE400B  | 0.01               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.07                 | 0.11 | 0.10 | 0.02                | 0.04 | 0.03 | 0.03      | 0.05 | 0.05 | 0.27                 | 0.39 | 0.45 |
| HE450A  | 0.00               | 0.01 | 0.01 | 0.02       | 0.03 | 0.03 | 0.06                 | 0.09 | 0.08 | 0.02                | 0.03 | 0.02 | 0.03      | 0.04 | 0.04 | 0.22                 | 0.33 | 0.38 |
| HE450B  | 0.00               | 0.01 | 0.01 | 0.02       | 0.03 | 0.02 | 0.06                 | 0.09 | 0.07 | 0.02                | 0.03 | 0.02 | 0.03      | 0.04 | 0.04 | 0.21                 | 0.32 | 0.37 |
| HE500A  | 0.00               | 0.01 |      | 0.01       | 0.02 |      | 0.05                 | 0.07 |      | 0.02                | 0.02 |      | 0.02      | 0.03 |      | 0.17                 | 0.27 |      |
| HE500B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.02 | 0.02 | 0.05                 | 0.07 | 0.06 | 0.01                | 0.02 | 0.02 | 0.02      | 0.03 | 0.03 | 0.17                 | 0.26 | 0.30 |

**Table A1.20:** Ratio  $M_{\text{splice}}/M_{\text{Rd}}$ ,  $L = 8 \text{ m}$ ,  $H_{\text{spl}} = 0.8L$ 

| Section | Fixed-fixed column |      |      |            |      |      | Pinned-pinned column |      |      | Fixed-guided column |      |      |           |      |      | Pinned-guided column |      |      |
|---------|--------------------|------|------|------------|------|------|----------------------|------|------|---------------------|------|------|-----------|------|------|----------------------|------|------|
|         | $K = 0.5$          |      |      | $K = 0.65$ |      |      | $K = 1.0$            |      |      | $K = 1.0$           |      |      | $K = 1.2$ |      |      | $K = 2.0$            |      |      |
|         | S235               | S355 | S460 | S235       | S355 | S460 | S235                 | S355 | S460 | S235                | S355 | S460 | S235      | S355 | S460 | S235                 | S355 | S460 |
| HE100A  | 0.13               | 0.18 | 0.19 | 0.19       | 0.22 | 0.23 | 0.47                 | 0.51 | 0.52 | 0.65                | 0.70 | 0.72 | 0.70      | 0.73 | 0.75 | 0.90                 | 0.92 | 0.92 |
| HE100B  | 0.13               | 0.17 | 0.18 | 0.18       | 0.22 | 0.23 | 0.47                 | 0.51 | 0.52 | 0.65                | 0.70 | 0.72 | 0.69      | 0.73 | 0.74 | 0.90                 | 0.92 | 0.92 |
| HE120A  | 0.10               | 0.14 | 0.15 | 0.15       | 0.19 | 0.20 | 0.43                 | 0.48 | 0.50 | 0.59                | 0.66 | 0.68 | 0.65      | 0.70 | 0.72 | 0.88                 | 0.90 | 0.91 |
| HE120B  | 0.09               | 0.13 | 0.14 | 0.14       | 0.18 | 0.20 | 0.42                 | 0.47 | 0.49 | 0.58                | 0.65 | 0.68 | 0.64      | 0.70 | 0.72 | 0.88                 | 0.90 | 0.91 |
| HE140A  | 0.07               | 0.11 | 0.11 | 0.12       | 0.16 | 0.17 | 0.38                 | 0.44 | 0.47 | 0.53                | 0.61 | 0.64 | 0.60      | 0.67 | 0.69 | 0.85                 | 0.89 | 0.90 |
| HE140B  | 0.07               | 0.10 | 0.10 | 0.11       | 0.15 | 0.17 | 0.37                 | 0.43 | 0.46 | 0.51                | 0.60 | 0.63 | 0.59      | 0.66 | 0.68 | 0.85                 | 0.88 | 0.90 |
| HE160A  | 0.06               | 0.08 | 0.08 | 0.09       | 0.13 | 0.14 | 0.34                 | 0.41 | 0.43 | 0.46                | 0.56 | 0.59 | 0.55      | 0.63 | 0.66 | 0.83                 | 0.87 | 0.88 |
| HE160B  | 0.05               | 0.08 | 0.08 | 0.09       | 0.13 | 0.13 | 0.32                 | 0.40 | 0.42 | 0.45                | 0.55 | 0.58 | 0.53      | 0.62 | 0.65 | 0.82                 | 0.86 | 0.88 |
| HE180A  | 0.05               | 0.07 | 0.06 | 0.07       | 0.11 | 0.11 | 0.29                 | 0.37 | 0.39 | 0.40                | 0.50 | 0.54 | 0.49      | 0.58 | 0.61 | 0.79                 | 0.84 | 0.86 |
| HE180B  | 0.04               | 0.06 | 0.06 | 0.07       | 0.10 | 0.11 | 0.28                 | 0.36 | 0.38 | 0.38                | 0.49 | 0.53 | 0.48      | 0.57 | 0.60 | 0.79                 | 0.84 | 0.86 |
| HE200A  | 0.04               | 0.06 | 0.05 | 0.06       | 0.09 | 0.09 | 0.25                 | 0.33 | 0.35 | 0.34                | 0.45 | 0.49 | 0.44      | 0.54 | 0.57 | 0.76                 | 0.82 | 0.84 |
| HE200B  | 0.04               | 0.05 | 0.05 | 0.06       | 0.08 | 0.08 | 0.24                 | 0.31 | 0.34 | 0.32                | 0.43 | 0.47 | 0.42      | 0.52 | 0.56 | 0.75                 | 0.81 | 0.84 |
| HE220A  | 0.03               | 0.05 | 0.04 | 0.05       | 0.07 | 0.07 | 0.21                 | 0.29 | 0.31 | 0.29                | 0.40 | 0.43 | 0.38      | 0.49 | 0.53 | 0.72                 | 0.79 | 0.82 |
| HE220B  | 0.03               | 0.04 | 0.04 | 0.05       | 0.07 | 0.07 | 0.20                 | 0.28 | 0.30 | 0.28                | 0.38 | 0.41 | 0.37      | 0.48 | 0.51 | 0.71                 | 0.79 | 0.81 |
| HE240A  | 0.03               | 0.04 | 0.03 | 0.04       | 0.06 | 0.06 | 0.18                 | 0.25 | 0.27 | 0.25                | 0.35 | 0.37 | 0.33      | 0.44 | 0.48 | 0.69                 | 0.77 | 0.80 |
| HE240B  | 0.02               | 0.04 | 0.03 | 0.04       | 0.06 | 0.05 | 0.17                 | 0.24 | 0.26 | 0.24                | 0.33 | 0.36 | 0.32      | 0.43 | 0.47 | 0.67                 | 0.76 | 0.79 |
| HE260A  | 0.02               | 0.03 | 0.03 | 0.04       | 0.05 | 0.05 | 0.15                 | 0.22 | 0.23 | 0.21                | 0.30 | 0.32 | 0.29      | 0.40 | 0.43 | 0.64                 | 0.73 | 0.77 |
| HE260B  | 0.02               | 0.03 | 0.03 | 0.03       | 0.05 | 0.05 | 0.15                 | 0.21 | 0.22 | 0.20                | 0.29 | 0.31 | 0.28      | 0.39 | 0.42 | 0.63                 | 0.73 | 0.76 |
| HE280A  | 0.02               | 0.03 |      | 0.03       | 0.05 |      | 0.13                 | 0.19 |      | 0.18                | 0.27 |      | 0.25      | 0.36 |      | 0.60                 | 0.70 |      |
| HE280B  | 0.02               | 0.03 | 0.02 | 0.03       | 0.04 | 0.04 | 0.13                 | 0.19 | 0.19 | 0.18                | 0.26 | 0.26 | 0.25      | 0.35 | 0.37 | 0.59                 | 0.69 | 0.73 |
| HE300A  | 0.02               | 0.02 | 0.02 | 0.03       | 0.04 | 0.03 | 0.12                 | 0.17 | 0.17 | 0.16                | 0.23 | 0.23 | 0.22      | 0.32 | 0.34 | 0.56                 | 0.67 | 0.71 |
| HE300B  | 0.01               | 0.02 | 0.02 | 0.03       | 0.04 | 0.03 | 0.11                 | 0.16 | 0.16 | 0.16                | 0.23 | 0.22 | 0.22      | 0.31 | 0.33 | 0.55                 | 0.66 | 0.70 |
| HE320A  | 0.01               | 0.02 | 0.02 | 0.02       | 0.04 | 0.03 | 0.10                 | 0.15 | 0.15 | 0.14                | 0.21 | 0.20 | 0.20      | 0.29 | 0.30 | 0.52                 | 0.64 | 0.68 |
| HE320B  | 0.01               | 0.02 | 0.02 | 0.02       | 0.03 | 0.03 | 0.10                 | 0.15 | 0.14 | 0.14                | 0.20 | 0.20 | 0.19      | 0.28 | 0.29 | 0.51                 | 0.63 | 0.67 |
| HE340A  | 0.01               | 0.02 | 0.02 | 0.02       | 0.03 | 0.03 | 0.09                 | 0.14 | 0.13 | 0.13                | 0.19 | 0.18 | 0.18      | 0.26 | 0.27 | 0.49                 | 0.61 | 0.65 |
| HE340B  | 0.01               | 0.02 | 0.02 | 0.02       | 0.03 | 0.03 | 0.09                 | 0.13 | 0.12 | 0.12                | 0.18 | 0.17 | 0.17      | 0.25 | 0.26 | 0.48                 | 0.60 | 0.64 |
| HE360A  | 0.01               | 0.02 | 0.01 | 0.02       | 0.03 | 0.02 | 0.08                 | 0.12 | 0.11 | 0.12                | 0.17 | 0.16 | 0.16      | 0.24 | 0.24 | 0.45                 | 0.58 | 0.62 |
| HE360B  | 0.01               | 0.02 | 0.01 | 0.02       | 0.03 | 0.02 | 0.08                 | 0.12 | 0.11 | 0.11                | 0.16 | 0.15 | 0.16      | 0.23 | 0.23 | 0.44                 | 0.57 | 0.61 |
| HE400A  | 0.00               | 0.01 | 0.01 | 0.01       | 0.01 | 0.01 | 0.05                 | 0.07 | 0.06 | 0.06                | 0.10 | 0.09 | 0.09      | 0.14 | 0.14 | 0.33                 | 0.47 | 0.53 |
| HE400B  | 0.00               | 0.01 | 0.01 | 0.01       | 0.01 | 0.01 | 0.04                 | 0.07 | 0.06 | 0.06                | 0.09 | 0.08 | 0.09      | 0.14 | 0.13 | 0.32                 | 0.46 | 0.52 |
| HE450A  | 0.00               | 0.01 | 0.01 | 0.01       | 0.01 | 0.01 | 0.04                 | 0.05 | 0.05 | 0.05                | 0.08 | 0.07 | 0.07      | 0.11 | 0.10 | 0.25                 | 0.39 | 0.45 |
| HE450B  | 0.00               | 0.01 | 0.00 | 0.01       | 0.01 | 0.01 | 0.03                 | 0.05 | 0.05 | 0.05                | 0.07 | 0.06 | 0.07      | 0.11 | 0.10 | 0.25                 | 0.38 | 0.44 |
| HE500A  | 0.00               | 0.00 |      | 0.00       | 0.01 |      | 0.03                 | 0.04 |      | 0.04                | 0.06 |      | 0.06      | 0.09 |      | 0.20                 | 0.32 |      |
| HE500B  | 0.00               | 0.00 | 0.00 | 0.00       | 0.01 | 0.01 | 0.03                 | 0.04 | 0.04 | 0.04                | 0.06 | 0.05 | 0.06      | 0.09 | 0.08 | 0.20                 | 0.31 | 0.35 |

