



**PROGRAM** : NATIONAL DIPLOMA  
BUILDING

**SUBJECT** : STRUCTURES AND CONCRETE

**CODE** : SAC3000  
SAC331

**DATE** : SSA EXAMINATION  
9 JANUARY 2017

**DURATION** : (SESSION 1) 8:00 -11:00

**WEIGHT** : 50:50

**TOTAL MARKS** : 100

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**ASSESOR** : DR I. MUSONDA File Number

**MODERATOR** : MR F. THAIMO 2300

**NUMBER OF PAGES** : 4 PAGES

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**REQUIREMENTS** : FORMULA SHEETS AND TABLES

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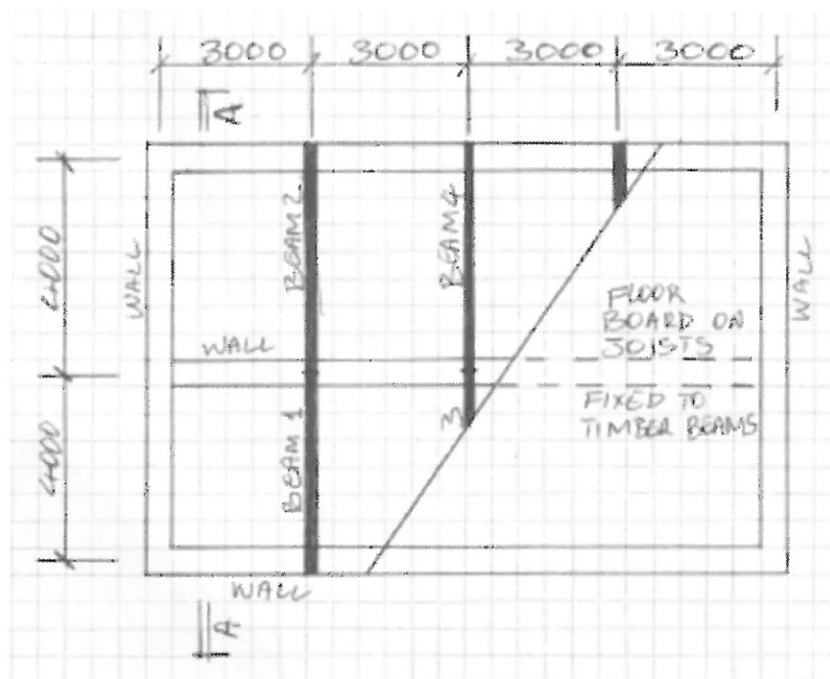
**INSTRUCTIONS TO CANDIDATES:**

PLEASE ANSWER ALL THE QUESTIONS. WRITE CLEARLY AND LEGIBLY.  
ANSWERS SHOULD BE NUMBERED AS PER THE QUESTIONS.

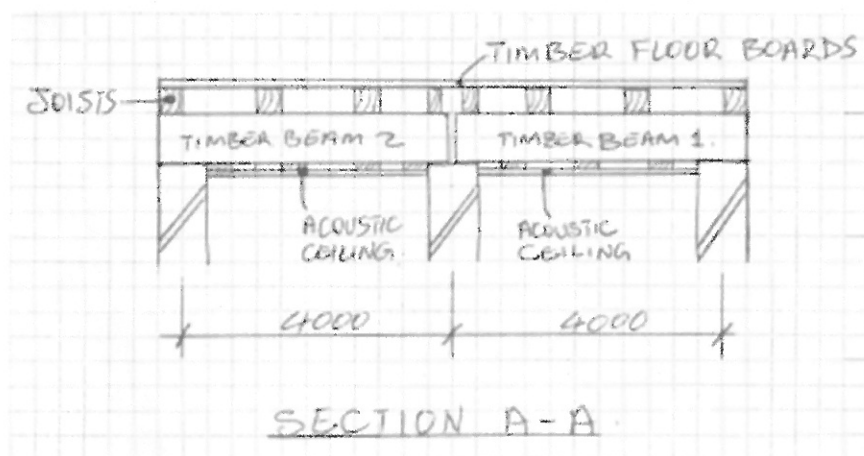
### Question 1.0 [20]

A timber floor forming part of a residential house is constructed as shown in Figure 1.0 below. The main timber beams (beam 1- 4) spanning 4000mm over wall supports, support 50x75mm timber joists and timber floor boards. Use the information provided on the drawing and the tables in the formula book to determine the following:

- 1.1 Total ultimate design load applied on the main timber beams
- 1.2 The depth of the main timber beams that may be used to sustain the applied loads if the width of the beams should be 100mm and have  $8.5\text{N/mm}^2$  yield stress. Take the weight of timber beams to be  $0.6\text{kN}$ .



FLOOR PLAN

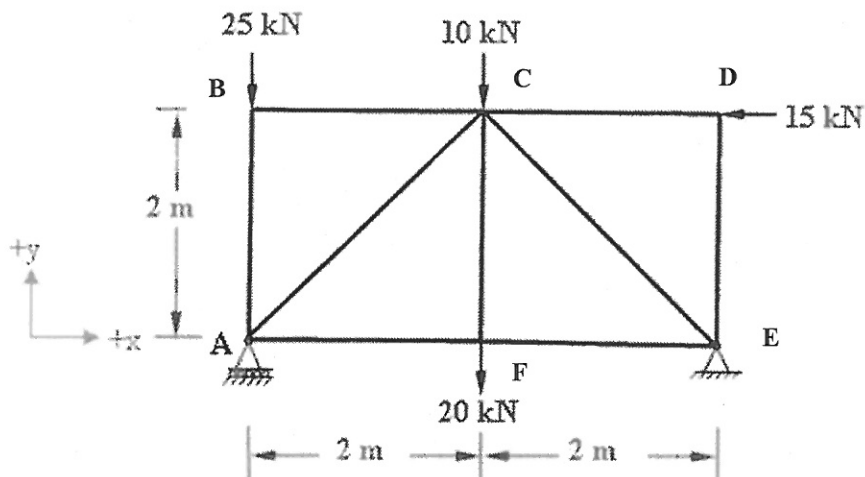


SECTION A - A

**FIGURE 1.0**

### **Question 2.0 [20]**

Determine the magnitude and type of forces in all members of the truss shown in Figure 2.0 below. In addition, determine the reactions at the supports.



**Figure 2.0**

### **Question 3.0 [20]**

A concrete beam, size 230mm x 400mm deep, is simply supported and has a span of 4000mm. It supports a dead load of 100kN and an imposed load of 40kN. Determine the steel reinforcement required to effectively support the loads. Take the effective depth to be 354.5mm and the characteristic strengths of materials to be as follows:

$$f_{cu} = 30\text{Mpa}, f_y = 450\text{Mpa}, f_{yv} = 250\text{Mpa}$$

### **Question 4.0 [20]**

A simply supported beam spans 6.0m between two supports and carries a design uniformly distributed load (UDL) of 72kN. The top flange is fully restrained against lateral buckling. Select a suitable mild steel standard I-beam to carry this load using the plastic theory and check for shear. Use the maximum yield stress of 165mpa.

**Question 5.0 [20]**

A one-way, simply-supported reinforced concrete slab has an effective depth of 135mm and an effective span of 3750 mm. The slab is reinforced with R25 bars spaced at 300mm center to center.. Use concrete cover of 25mm.

GIVEN:       $f_{cu}$     = 30MPa  
                  $f_y$      = 250 MPa  
                  $b$       = 1000 mm  
                  $\rho_{con}$  = 25kN/m<sup>3</sup>

- i) Determine the self-weight of the slab (dead load). Use a rounded off slab thickness
- ii) Calculate the maximum uniformly- distributed load per square meter that the slab can safely withhold.

**FORMULAS AND TABLES FOR USE IN NOVEMBER AND DECEMBER SAC3000  
NOVEMBER/DECEMBER EXAMINATION (2015)**

**ND. BUILDING**

**ANY APPLICABLE FORMULA BELOW MAY BE USED FOR BEAM DESIGN**

$$M = \sigma \times Z$$

$$\bar{X} = \frac{\sum \bar{x}_i A_i}{A_T}$$

$$\frac{I_{NA}}{y} = Z_e$$

$$\bar{Y} = \frac{\sum \bar{y}_i A_i}{A_T}$$

$$Z_e = \frac{BD^2}{6} \text{ for a rectangular section}$$

$$M = \frac{\sigma}{y} \times I$$

$$\frac{M}{I} = \frac{E}{R} = \frac{\sigma}{y}$$

$$I_{XX} = \frac{bd^3}{12} \text{ For a rectangular shape}$$

$$I_{XX} = (I_{x1} + Ad_1^2) + (I_{x2} + Ad_2^2) + (I_{xi} + Ad_i^2) \text{ Where d is the difference between } \bar{y} \text{ and } \bar{Y}$$

$$M_{\max} = \frac{PL}{4}$$

$$M_{\max} = \frac{wl^2}{8}$$

$$V_{ave} = \frac{V}{D \times t}$$

$$V_{\max} = 0.6 \times \sigma_y$$

**FORMULAE RECTANGULAR CONCRETE BEAM DESIGN IN BENDING**

$$\frac{M}{f_{cu} b d^2} = k$$

$$A_s = \frac{M}{0.87 f_y z}$$

$$z = d \left[ 0.5 + \sqrt{\left( 0.25 - \frac{k}{0.9} \right)} \right]$$

$$A'_s = \frac{(k - k') b d^2 f_{cu}}{f_{yc} (d - d')}$$

$$A_s = \frac{k' f_{cu} b d^2}{0.87 f_y} + \frac{f_{yc}}{0.87 f_y} A_s'$$

$$\frac{100 A_s}{b h} \leq 4\%$$

$$K' = 0.156$$

$$f_{yc} = 327 \text{ N/mm}^2$$

#### FORMULAE FOR CONCRETE BEAM SHEAR DESIGN

$$v = \frac{V}{b \times d}$$

$$v_c = \frac{0.75}{\gamma_m} \left( \frac{f_{cu}}{25} \right)^{1/3} \left( \frac{100 A_s}{b d} \right)^{1/3} \left( \frac{400}{d} \right)^{1/4}$$

$$\frac{A_{sv}}{S_v} = \frac{(v - v_c) b}{0.87 f_{yv}}$$

$$\gamma_m = 1.4$$

#### FORMULAE FOR DEFLECTION

$$\text{Modification factor} = 0.55 + \frac{(477 - f_s)}{120 \left( 0.9 + \frac{M}{b d^2} \right)} \leq 2.0$$

$$f_s = \frac{5^*}{8} \times \frac{f_y A_{s, \text{req}}}{A_{s, \text{prov}}}$$

#### BASIC SPAN/DEPTH RATIOS

| Support conditions | Rectangular sections | Flanged beams with $\frac{\text{width of beam}}{\text{width of flange}} \leq 0.3$ |
|--------------------|----------------------|-----------------------------------------------------------------------------------|
| Cantilever         | 7                    | 5.6                                                                               |
| Simply supported   | 20                   | 16.0                                                                              |
| Continuous         | 26                   | 20.8                                                                              |

**Table 1 – imposed loads on floors, balconies and stairs in buildings**

| 1        | 2                                                                                                          | 3            | 4                                                                                                                                                                                                                                                                                                                                                                                             | 5                               | 6             |
|----------|------------------------------------------------------------------------------------------------------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------|
| Category | Specific use                                                                                               | Sub-category | Example                                                                                                                                                                                                                                                                                                                                                                                       | $q_k$<br>$kN / m^2$             | $Q_k$<br>$kN$ |
| A        | Areas for domestic and residential activities                                                              | A1           | All rooms is a dwelling unit and a dwelling house, including corridors and lobbies                                                                                                                                                                                                                                                                                                            | 1.5                             | 1.5           |
|          |                                                                                                            | A2           | Bedrooms, wards, dormitories, private bathrooms and toilets in hospitals, hotels, hostels and other institutional residential occupancies                                                                                                                                                                                                                                                     | 2.0                             | 1.5           |
|          |                                                                                                            | A3           | Stairs and escape routes in residential occupancies for example, serving hospitals, hotels, hostels and other institutional residential occupancies.                                                                                                                                                                                                                                          | 3.0                             | 1.5           |
|          |                                                                                                            | A4           | Balconies accessible to domestic and residential occupancy areas.                                                                                                                                                                                                                                                                                                                             | 4.0                             | 3.0           |
| B        | Public areas (not susceptible to crowding)                                                                 | B1           | Office areas for general use                                                                                                                                                                                                                                                                                                                                                                  | 2.5                             | 4.5           |
|          |                                                                                                            | B2           | Public libraries, excluding stack areas                                                                                                                                                                                                                                                                                                                                                       | 3.0                             | 4.5           |
|          |                                                                                                            | B3           | Kitchens, communal bathrooms and toilets in educational buildings, hotels, office buildings and other institutional occupancies                                                                                                                                                                                                                                                               | 3.0                             | 5.0           |
|          |                                                                                                            | B4           | Light laboratories, operating theatres, X-ray rooms                                                                                                                                                                                                                                                                                                                                           | 3.0                             | 5.0           |
|          |                                                                                                            | B5           | Filling and office storage areas, stack areas in libraries and archives                                                                                                                                                                                                                                                                                                                       | 2.5 per m stack height but >5.0 | 5.0           |
| C        | Public areas where people may congregate ( with the exception of areas defined under category A, B, and D) | C1           | Areas with movable furniture, tables etc. E.g. classrooms, areas in schools, cafes, restaurants, dining halls, reading rooms, reception areas, banking halls                                                                                                                                                                                                                                  | 3.0                             | 5.0           |
|          |                                                                                                            | C2           | Areas with fixed seats, e.g. areas in churches, theatres or cinemas, conference rooms, lecture halls, assembly halls, waiting rooms, railway waiting rooms; grandstands with fixed individual seating                                                                                                                                                                                         | 4.0                             | 3.0           |
|          |                                                                                                            | C3           | Areas without obstacles for moving people, all without fixed individual seating e.g. assembly halls and areas, sport complexes, grandstands, areas in museums, exhibition rooms, etc. And access areas in public and administration buildings, hotels, hospitals, airports, railway station forecourts and terminals; stairs, corridors, landings; cantilever balconies accessible to public. | 5.0                             | 3.0           |

**Table 2 – imposed loads on floors due to industrial use and storage**

| 1        | 2                                                                  | 3                                                                    | 4                               | 5             |
|----------|--------------------------------------------------------------------|----------------------------------------------------------------------|---------------------------------|---------------|
| Category | Specific use                                                       | Example                                                              | $q_k$<br>$kN/m^2$               | $Q_k$<br>$kN$ |
| E1       | Light industrial use                                               | Production rooms such as workshops with light equipment (<5kN each)  | 3.0                             | 5.0           |
| E2       | Industrial use                                                     | Production rooms such as workshops in works and factories            | 5.0                             | 5.0           |
| E3       | Areas susceptible to accumulation of goods, including access areas | Areas for storage use including storage of books and other documents | 2.5 per m stack height but >5.0 | 5.0           |
| E4       | Access ladders and walkways                                        | Maintenance walkways in buildings                                    | 1.5                             | 1.5           |

**Table 3A – weights of materials**

| Material                          | Mass density<br>$KN/m^3$ |
|-----------------------------------|--------------------------|
| plaster cement & sand             | 23.0                     |
| gypsum                            | 17.0                     |
| Reinforced concrete               | 25.0                     |
| Clay bricks                       | 19.0                     |
| Natural aggregate concrete bricks | 22.0                     |
| Light hollow concrete blocks      | 12.0                     |
| Timber                            | 5.0                      |
| Steel                             | 70.0                     |
| Aluminium                         | 28.0                     |
| Glass                             | 25.0                     |

Table 3 B- weights of materials

| Materials                   | Unit weight KN/m <sup>2</sup> |
|-----------------------------|-------------------------------|
| Acoustic ceiling tiles      | 0.1                           |
| Asphalt(19mm)               | 0.45                          |
| Sand / cement screed (25mm) | 0.6                           |
| Vinyl tiles                 | 0.05                          |
| Slates                      | 0.6                           |
| Steel roof sheeting         | 0.15                          |
| Timber floorboards          | 0.15                          |

**TABLES FROM SABS 0100-1**

**Table 4:** Typical\* partial factors of safety for loads  $\gamma_f$ .

| Load combination                               | Ultimate limit state |              |              | Serviceability limit state |              |              |
|------------------------------------------------|----------------------|--------------|--------------|----------------------------|--------------|--------------|
|                                                | Self-weight load     | Imposed load | Wind load    | Self-weight load           | Imposed load | Wind load    |
| Self-weight load                               | 1.5<br>(0.9)         | —            | —            | 1.1<br>(1.0)               | —            | —            |
| Self-weight load<br>+ live load                | 1.2<br>(0.9)         | 1.6<br>(0)   | —            | 1.1<br>(1.0)               | 1.0<br>(0)   | —            |
| Self-weight load<br>+ live load<br>+ wind load | 1.2<br>(0.9)         | 0.5<br>(0)   | 1.3<br>(1.3) | 1.1<br>(1.0)               | 0.3<br>(0)   | 0.6<br>(0.6) |

\* See SABS 0160 (1989) for a complete discussion on loads and their combinations.

Table 9:  $A_{sv}/s_v$  (mm<sup>2</sup>/mm) for links with two legs

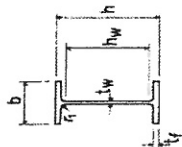
| Diameter<br>(mm) | Link spacing (mm) |       |       |       |       |       |       |       |       |       |       |
|------------------|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                  | 75                | 100   | 125   | 150   | 200   | 250   | 300   | 350   | 400   | 450   | 500   |
| 8                | 1.340             | 1.005 | 0.804 | 0.670 | 0.503 | 0.402 | 0.335 | 0.287 | 0.251 | 0.223 | 0.201 |
| 10               | 2.094             | 1.571 | 1.257 | 1.047 | 0.785 | 0.628 | 0.524 | 0.449 | 0.393 | 0.349 | 0.314 |
| 12               | 3.016             | 2.262 | 1.810 | 1.508 | 1.131 | 0.905 | 0.754 | 0.646 | 0.565 | 0.503 | 0.452 |
| 16               | 5.362             | 4.021 | 3.217 | 2.681 | 2.011 | 1.608 | 1.340 | 1.149 | 1.005 | 0.894 | 0.804 |

**Table 31:** Reinforcement areas (mm<sup>2</sup>).

| No | Bar diameter (mm) |      |       |       |       |       |       |        |
|----|-------------------|------|-------|-------|-------|-------|-------|--------|
|    | 8                 | 10   | 12    | 16    | 20    | 25    | 32    | 40     |
| 1  | 50.3              | 78.5 | 113.1 | 201.1 | 314.2 | 490.9 | 804.2 | 1256.6 |
| 2  | 101               | 157  | 226   | 402   | 628   | 982   | 1608  | 2513   |
| 3  | 151               | 236  | 339   | 603   | 942   | 1473  | 2413  | 3770   |
| 4  | 201               | 314  | 452   | 804   | 1257  | 1963  | 3217  | 5027   |
| 5  | 251               | 393  | 565   | 1005  | 1571  | 2454  | 4021  | 6283   |
| 6  | 302               | 471  | 679   | 1206  | 1885  | 2945  | 4825  | 7540   |
| 7  | 352               | 550  | 792   | 1407  | 2199  | 3436  | 5630  | 8796   |
| 8  | 402               | 628  | 905   | 1608  | 2513  | 3927  | 6434  | 10053  |
| 9  | 452               | 707  | 1018  | 1810  | 2827  | 4418  | 7238  | 11310  |
| 10 | 503               | 785  | 1131  | 2011  | 3142  | 4909  | 8042  | 12566  |
| 11 | 553               | 864  | 1244  | 2212  | 3456  | 5400  | 8847  | 13823  |
| 12 | 603               | 942  | 1357  | 2413  | 3770  | 5890  | 9651  | 15080  |
| 13 | 653               | 1021 | 1470  | 2614  | 4084  | 6381  | 10455 | 16336  |
| 14 | 704               | 1100 | 1583  | 2815  | 4398  | 6872  | 11259 | 17593  |
| 15 | 754               | 1178 | 1696  | 3016  | 4712  | 7363  | 12064 | 18850  |
| 16 | 804               | 1257 | 1810  | 3217  | 5027  | 7854  | 12868 | 20106  |
| 17 | 855               | 1335 | 1923  | 3418  | 5341  | 8345  | 13672 | 21363  |
| 18 | 905               | 1414 | 2036  | 3619  | 5655  | 8836  | 14476 | 22619  |
| 19 | 955               | 1492 | 2149  | 3820  | 5969  | 9327  | 15281 | 23876  |
| 20 | 1005              | 1571 | 2262  | 4021  | 6283  | 9817  | 16085 | 25133  |
| 21 | 1056              | 1649 | 2375  | 4222  | 6597  | 10308 | 16889 | 26389  |
| 22 | 1106              | 1728 | 2488  | 4423  | 6912  | 10799 | 17693 | 27646  |
| 23 | 1156              | 1806 | 2601  | 4624  | 7226  | 11290 | 18498 | 28903  |
| 24 | 1206              | 1885 | 2714  | 4825  | 7540  | 11781 | 19302 | 30159  |
| 25 | 1257              | 1963 | 2827  | 5027  | 7854  | 12272 | 20106 | 31416  |
| 26 | 1307              | 2042 | 2941  | 5228  | 8168  | 12763 | 20910 | 32673  |
| 27 | 1357              | 2121 | 3054  | 5429  | 8482  | 13254 | 21715 | 33929  |
| 28 | 1407              | 2199 | 3167  | 5630  | 8796  | 13744 | 22519 | 35186  |
| 29 | 1458              | 2278 | 3280  | 5831  | 9111  | 14235 | 23323 | 36442  |
| 30 | 1508              | 2356 | 3393  | 6032  | 9425  | 14726 | 24127 | 37699  |
| 31 | 1558              | 2435 | 3506  | 6233  | 9739  | 15217 | 24932 | 38956  |
| 32 | 1608              | 2513 | 3619  | 6434  | 10053 | 15708 | 25736 | 40212  |
| 33 | 1659              | 2592 | 3732  | 6635  | 10367 | 16199 | 26540 | 41469  |
| 34 | 1709              | 2670 | 3845  | 6836  | 10681 | 16690 | 27344 | 42726  |
| 35 | 1759              | 2749 | 3958  | 7037  | 10996 | 17181 | 28149 | 43982  |
| 36 | 1810              | 2827 | 4072  | 7238  | 11310 | 17671 | 28953 | 45239  |
| 37 | 1860              | 2906 | 4185  | 7439  | 11624 | 18162 | 29757 | 46496  |
| 38 | 1910              | 2985 | 4298  | 7640  | 11938 | 18653 | 30561 | 47752  |
| 39 | 1960              | 3063 | 4411  | 7841  | 12252 | 19144 | 31366 | 49009  |
| 40 | 2011              | 3142 | 4524  | 8042  | 12566 | 19635 | 32170 | 50265  |

Table 30: Reinforcement areas (mm<sup>2</sup>/m).

| Spacing<br>(mm) | Bar diameter (mm) |      |      |      |       |       |       |       |
|-----------------|-------------------|------|------|------|-------|-------|-------|-------|
|                 | 8                 | 10   | 12   | 16   | 20    | 25    | 32    | 40    |
| 1000            | 50                | 79   | 113  | 201  | 314   | 491   | 804   | 1257  |
| 975             | 52                | 81   | 116  | 206  | 322   | 503   | 825   | 1289  |
| 950             | 53                | 83   | 119  | 212  | 331   | 517   | 847   | 1323  |
| 925             | 54                | 85   | 122  | 217  | 340   | 531   | 869   | 1359  |
| 900             | 56                | 87   | 126  | 223  | 349   | 545   | 894   | 1396  |
| 875             | 57                | 90   | 129  | 230  | 359   | 561   | 919   | 1436  |
| 850             | 59                | 92   | 133  | 237  | 370   | 577   | 946   | 1478  |
| 825             | 61                | 95   | 137  | 244  | 381   | 595   | 975   | 1523  |
| 800             | 63                | 98   | 141  | 251  | 393   | 614   | 1005  | 1571  |
| 775             | 65                | 101  | 146  | 259  | 405   | 633   | 1038  | 1621  |
| 750             | 67                | 105  | 151  | 268  | 419   | 654   | 1072  | 1676  |
| 725             | 69                | 108  | 156  | 277  | 433   | 677   | 1109  | 1733  |
| 700             | 72                | 112  | 162  | 287  | 449   | 701   | 1149  | 1795  |
| 675             | 74                | 116  | 168  | 298  | 465   | 727   | 1191  | 1862  |
| 650             | 77                | 121  | 174  | 309  | 483   | 755   | 1237  | 1933  |
| 625             | 80                | 126  | 181  | 322  | 503   | 785   | 1287  | 2011  |
| 600             | 84                | 131  | 188  | 335  | 524   | 818   | 1340  | 2094  |
| 575             | 87                | 137  | 197  | 350  | 546   | 854   | 1399  | 2185  |
| 550             | 91                | 143  | 206  | 366  | 571   | 892   | 1462  | 2285  |
| 525             | 96                | 150  | 215  | 383  | 598   | 935   | 1532  | 2394  |
| 500             | 101               | 157  | 226  | 402  | 628   | 982   | 1608  | 2513  |
| 475             | 106               | 165  | 238  | 423  | 661   | 1033  | 1693  | 2646  |
| 450             | 112               | 175  | 251  | 447  | 698   | 1091  | 1787  | 2793  |
| 425             | 118               | 185  | 266  | 473  | 739   | 1155  | 1892  | 2957  |
| 400             | 126               | 196  | 283  | 503  | 785   | 1227  | 2011  | 3142  |
| 375             | 134               | 209  | 302  | 536  | 838   | 1309  | 2145  | 3351  |
| 350             | 144               | 224  | 323  | 574  | 898   | 1402  | 2298  | 3590  |
| 325             | 155               | 242  | 348  | 619  | 967   | 1510  | 2475  | 3867  |
| 300             | 168               | 262  | 377  | 670  | 1047  | 1636  | 2681  | 4189  |
| 275             | 183               | 286  | 411  | 731  | 1142  | 1785  | 2925  | 4570  |
| 250             | 201               | 314  | 452  | 804  | 1257  | 1963  | 3217  | 5027  |
| 225             | 223               | 349  | 503  | 894  | 1396  | 2182  | 3574  | 5585  |
| 200             | 251               | 393  | 565  | 1005 | 1571  | 2454  | 4021  | 6283  |
| 175             | 287               | 449  | 646  | 1149 | 1795  | 2805  | 4596  | 7181  |
| 150             | 335               | 524  | 754  | 1340 | 2094  | 3272  | 5362  | 8378  |
| 125             | 402               | 628  | 905  | 1608 | 2513  | 3927  | 6434  | 10053 |
| 100             | 503               | 785  | 1131 | 2011 | 3142  | 4909  | 8042  | 12566 |
| 75              | 670               | 1047 | 1508 | 2681 | 4189  | 6545  | 10723 | 16755 |
| 50              | 1005              | 1571 | 2262 | 4021 | 6283  | 9817  | 16085 | 25133 |
| 25              | 2011              | 3142 | 4524 | 8042 | 12566 | 19635 | 32170 | 50265 |



## I-sections (parallel flange)

Dimensions and properties

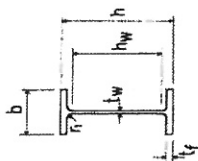
| Designation           | m    | h     | b     | t <sub>w</sub> | t <sub>f</sub> | r <sub>1</sub> | h <sub>w</sub> | A                               |
|-----------------------|------|-------|-------|----------------|----------------|----------------|----------------|---------------------------------|
| mm x mm x kg/m        | kg/m | mm    | mm    | mm             | mm             | mm             | mm             | 10 <sup>3</sup> mm <sup>2</sup> |
| IPE <sub>MA</sub> 100 | 6,72 | 97,6  | 55    | 3,6            | 4,5            | 7              | 74,6           | ,856                            |
| IPE 100               | 8,10 | 100   | 55    | 4,1            | 5,7            | 7              | 74,6           | 1,03                            |
| IPE <sub>MA</sub> 120 | 8,36 | 117   | 64    | 3,8            | 4,8            | 7              | 93,4           | 1,06                            |
| IPE 120               | 10,4 | 120   | 64    | 4,4            | 6,3            | 7              | 93,4           | 1,32                            |
| IPE <sub>MA</sub> 140 | 10,1 | 136,6 | 73    | 3,8            | 5,2            | 7              | 112            | 1,28                            |
| IPE 140               | 12,9 | 140   | 73    | 4,7            | 6,9            | 7              | 112            | 1,64                            |
| IPE <sub>MA</sub> 160 | 12,3 | 156,4 | 82    | 4              | 5,6            | 9              | 127            | 1,57                            |
| IPE 160               | 15,8 | 160   | 82    | 5              | 7,4            | 9              | 127            | 2,01                            |
| IPE <sub>MA</sub> 180 | 14,9 | 176,4 | 91    | 4,3            | 6,2            | 9              | 146            | 1,90                            |
| IPE 180               | 18,8 | 180   | 91    | 5,3            | 8              | 9              | 146            | 2,39                            |
| IPE <sub>MA</sub> 200 | 18   | 196,4 | 100   | 4,5            | 6,7            | 12             | 159            | 2,29                            |
| IPE 200               | 22,4 | 200   | 100   | 5,6            | 8,5            | 12             | 159            | 2,85                            |
| 152 x 89 x 16         | 16,1 | 152,4 | 88,9  | 4,6            | 7,7            | 7,6            | 122            | 2,05                            |
| 178 x 102 x 19        | 19   | 177,8 | 101,6 | 4,7            | 7,9            | 7,6            | 147            | 2,42                            |
| 203 x 133 x 25        | 25,3 | 203,2 | 133,4 | 5,8            | 7,8            | 7,6            | 172            | 3,22                            |
| 30                    | 29,8 | 206,8 | 133,8 | 6,3            | 9,6            | 7,6            | 172            | 3,80                            |
| 254 x 146 x 31        | 31,3 | 251,5 | 146,1 | 6,1            | 8,6            | 7,6            | 219            | 3,99                            |
| 37                    | 37,2 | 256   | 146,4 | 6,4            | 10,9           | 7,6            | 219            | 4,74                            |
| 43                    | 43,2 | 259,6 | 147,3 | 7,3            | 12,7           | 7,6            | 219            | 5,50                            |
| 305 x 102 x 25        | 24,5 | 304,8 | 101,6 | 5,8            | 6,8            | 7,6            | 276            | 3,12                            |
| 29                    | 28,6 | 308,9 | 101,9 | 6,1            | 8,9            | 7,6            | 276            | 3,64                            |
| 33                    | 32,8 | 312,7 | 102,4 | 6,6            | 10,8           | 7,6            | 276            | 4,18                            |



## I-sections (parallel flange)

Dimensions and properties

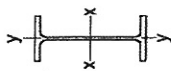
| About x-x                       |                                 |                                 |      | About y-y                       |                                 |                                 |      | J                               | C <sub>w</sub>                  |
|---------------------------------|---------------------------------|---------------------------------|------|---------------------------------|---------------------------------|---------------------------------|------|---------------------------------|---------------------------------|
| I                               | Z <sub>x</sub>                  | Z <sub>y</sub>                  | r    | I                               | Z <sub>x</sub>                  | Z <sub>y</sub>                  | r    | 10 <sup>8</sup> mm <sup>4</sup> | 10 <sup>6</sup> mm <sup>6</sup> |
| 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>3</sup> mm <sup>3</sup> | mm   | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>3</sup> mm <sup>3</sup> | mm   | 10 <sup>8</sup> mm <sup>4</sup> | 10 <sup>6</sup> mm <sup>6</sup> |
| 1,36                            | 27,8                            | 31,9                            | 39,8 | ,126                            | 4,57                            | 7,23                            | 12,1 | 7,33                            | ,272                            |
| 1,71                            | 34,2                            | 39,4                            | 40,7 | ,159                            | 5,78                            | 9,15                            | 12,4 | 12,1                            | ,364                            |
| 2,44                            | 41,7                            | 47,6                            | 47,9 | ,211                            | 6,59                            | 10,4                            | 14,1 | 9,55                            | ,663                            |
| 3,18                            | 53                              | 60,7                            | 49   | ,277                            | 8,65                            | 13,6                            | 14,6 | 17,4                            | ,894                            |
| 4,07                            | 59,7                            | 67,6                            | 56,4 | ,338                            | 9,27                            | 14,5                            | 16,3 | 12                              | 1,46                            |
| 5,41                            | 77,3                            | 86,3                            | 57,4 | ,449                            | 12,3                            | 19,2                            | 16,5 | 24,6                            | 1,99                            |
| 6,59                            | 84,3                            | 95,2                            | 64,8 | ,517                            | 12,6                            | 19,7                            | 18,1 | 18,2                            | 2,94                            |
| 8,69                            | 109                             | 124                             | 65,8 | ,683                            | 16,7                            | 26,1                            | 18,4 | 36,2                            | 3,98                            |
| 10,2                            | 116                             | 130                             | 73,2 | ,781                            | 17,2                            | 26,7                            | 20,3 | 24,9                            | 5,86                            |
| 13,2                            | 146                             | 166                             | 74,2 | 1,01                            | 22,2                            | 34,6                            | 20,5 | 48,1                            | 7,46                            |
| 15,3                            | 156                             | 176                             | 81,9 | 1,12                            | 22,4                            | 35                              | 22,1 | 38,7                            | 10,1                            |
| 19,4                            | 194                             | 221                             | 82,6 | 1,42                            | 28,5                            | 44,6                            | 22,4 | 70,2                            | 13,1                            |
| 8,38                            | 110                             | 124                             | 64   | ,904                            | 20,3                            | 31,4                            | 21   | 36,1                            | 4,73                            |
| 13,6                            | 153                             | 171                             | 74,9 | 1,38                            | 27,2                            | 41,9                            | 23,9 | 43,8                            | 9,98                            |
| 23,5                            | 231                             | 259                             | 85,4 | 3,09                            | 46,3                            | 71,2                            | 31   | 62,1                            | 29,5                            |
| 28,9                            | 279                             | 313                             | 87,2 | 3,84                            | 57,4                            | 88                              | 31,8 | 103                             | 37,3                            |
| 44,3                            | 352                             | 395                             | 105  | 4,48                            | 61,3                            | 94,2                            | 33,5 | 88,2                            | 66                              |
| 55,5                            | 433                             | 485                             | 108  | 5,71                            | 78                              | 119                             | 34,7 | 155                             | 85,7                            |
| 65,5                            | 505                             | 568                             | 109  | 6,77                            | 92                              | 141                             | 35,1 | 242                             | 103                             |
| 43,6                            | 286                             | 336                             | 118  | 1,19                            | 23,5                            | 37,8                            | 19,6 | 48                              | 26,5                            |
| 54,4                            | 352                             | 408                             | 122  | 1,58                            | 30,9                            | 49,2                            | 20,8 | 78,3                            | 35,5                            |
| 65                              | 416                             | 481                             | 125  | 1,94                            | 37,9                            | 60                              | 21,5 | 123                             | 44,2                            |



### I-sections (parallel flange)

Dimensions and properties

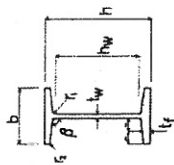
| Designation    | m    | h     | b     | t <sub>w</sub> | t <sub>f</sub> | r <sub>f</sub> | h <sub>w</sub> | A                               |
|----------------|------|-------|-------|----------------|----------------|----------------|----------------|---------------------------------|
| mm x mm x kg/m | kg/m | mm    | mm    | mm             | mm             | mm             | mm             | 10 <sup>3</sup> mm <sup>2</sup> |
| 305 x 165 x 41 | 40,5 | 303,8 | 165,1 | 6,1            | 10,2           | 8,9            | 266            | 5,16                            |
| 46             | 46,1 | 307,1 | 165,7 | 6,7            | 11,8           | 8,9            | 266            | 5,88                            |
| 54             | 53,5 | 310,9 | 166,8 | 7,7            | 13,7           | 8,9            | 266            | 6,82                            |
| 356 x 171 x 45 | 44,8 | 352   | 171   | 6,9            | 9,7            | 10,2           | 312            | 5,70                            |
| 51             | 50,7 | 355,6 | 171,5 | 7,3            | 11,5           | 10,2           | 312            | 6,46                            |
| 57             | 56,7 | 358,6 | 172,1 | 8              | 13             | 10,2           | 312            | 7,22                            |
| 67             | 67,2 | 364   | 173,2 | 9,1            | 15,7           | 10,2           | 312            | 8,55                            |
| 406 x 140 x 39 | 38,6 | 397,3 | 141,8 | 6,3            | 8,6            | 10,2           | 360            | 4,92                            |
| 46             | 46,3 | 402,3 | 142,4 | 6,9            | 11,2           | 10,2           | 359            | 5,90                            |
| 406 x 178 x 54 | 53,8 | 402,6 | 177,6 | 7,6            | 10,9           | 10,2           | 360            | 6,88                            |
| 60             | 59,7 | 406,4 | 177,8 | 7,8            | 12,8           | 10,2           | 360            | 7,61                            |
| 67             | 67,1 | 409,4 | 178,8 | 8,8            | 14,3           | 10,2           | 360            | 8,55                            |
| 75             | 74,8 | 412,8 | 179,7 | 9,7            | 16             | 10,2           | 360            | 9,53                            |
| 457 x 191 x 67 | 67,1 | 453,6 | 189,9 | 8,5            | 12,7           | 10,2           | 408            | 8,55                            |
| 75             | 74,7 | 457,2 | 190,5 | 9,1            | 14,5           | 10,2           | 408            | 9,51                            |
| 82             | 82   | 460,2 | 191,3 | 9,9            | 16             | 10,2           | 408            | 10,5                            |
| 90             | 89,7 | 463,6 | 192   | 10,6           | 17,7           | 10,2           | 408            | 11,4                            |
| 98             | 98,4 | 467,6 | 192,8 | 11,4           | 19,6           | 10,2           | 408            | 12,5                            |
| 533 x 210 x 82 | 82,2 | 528,3 | 208,7 | 9,6            | 13,2           | 12,7           | 476            | 10,5                            |
| 93             | 92,5 | 533,1 | 209,3 | 10,2           | 15,6           | 12,7           | 476            | 11,8                            |
| 101            | 101  | 536,7 | 210,1 | 10,9           | 17,4           | 12,7           | 476            | 12,9                            |
| 109            | 109  | 539,5 | 210,7 | 11,6           | 18,8           | 12,7           | 476            | 13,9                            |
| 122            | 122  | 544,6 | 211,9 | 12,8           | 21,3           | 12,7           | 477            | 15,6                            |



### I-sections (parallel flange)

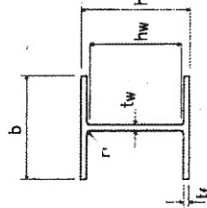
Dimensions and properties

| I    | About x-x                       |                                                   |                                                   |         | About y-y                       |                                                   |                                                   |         | J    | C <sub>w</sub> |
|------|---------------------------------|---------------------------------------------------|---------------------------------------------------|---------|---------------------------------|---------------------------------------------------|---------------------------------------------------|---------|------|----------------|
|      | 10 <sup>8</sup> mm <sup>4</sup> | Z <sub>x</sub><br>10 <sup>3</sup> mm <sup>3</sup> | Z <sub>p</sub><br>10 <sup>3</sup> mm <sup>3</sup> | r<br>mm | 10 <sup>8</sup> mm <sup>4</sup> | Z <sub>y</sub><br>10 <sup>3</sup> mm <sup>3</sup> | Z <sub>p</sub><br>10 <sup>3</sup> mm <sup>3</sup> | r<br>mm |      |                |
| 85,5 | 563                             | 626                                               | 773                                               | 129     | 7,66                            | 92,8                                              | 142                                               | 38,5    | 149  | 165            |
| 99,3 | 647                             | 722                                               | 895                                               | 130     | 8,96                            | 108                                               | 166                                               | 39      | 223  | 195            |
| 117  | 752                             | 843                                               | 1010                                              | 131     | 10,6                            | 127                                               | 195                                               | 39,4    | 345  | 234            |
| 121  | 686                             | 773                                               | 895                                               | 146     | 8,10                            | 94,7                                              | 146                                               | 37,7    | 160  | 237            |
| 142  | 796                             | 895                                               | 1010                                              | 148     | 9,88                            | 113                                               | 174                                               | 38,7    | 238  | 287            |
| 161  | 896                             | 1010                                              | 1111                                              | 149     | 11,1                            | 129                                               | 198                                               | 38,1    | 334  | 330            |
| 195  | 1070                            | 1210                                              | 151                                               | 151     | 13,6                            | 157                                               | 243                                               | 39,9    | 560  | 413            |
| 124  | 625                             | 718                                               | 889                                               | 159     | 4,10                            | 57,8                                              | 90,7                                              | 28,9    | 108  | 155            |
| 157  | 779                             | 889                                               | 1050                                              | 163     | 5,40                            | 75,9                                              | 119                                               | 30,3    | 194  | 207            |
| 187  | 927                             | 1050                                              | 1200                                              | 165     | 10,2                            | 115                                               | 178                                               | 38,6    | 233  | 391            |
| 215  | 1060                            | 1200                                              | 1350                                              | 168     | 12                              | 135                                               | 208                                               | 39,7    | 332  | 465            |
| 243  | 1190                            | 1350                                              | 1510                                              | 169     | 13,6                            | 153                                               | 237                                               | 39,9    | 465  | 533            |
| 274  | 1330                            | 1510                                              | 170                                               | 170     | 15,5                            | 173                                               | 268                                               | 40,3    | 642  | 610            |
| 294  | 1300                            | 1470                                              | 185                                               | 185     | 14,5                            | 153                                               | 237                                               | 41,2    | 376  | 706            |
| 334  | 1460                            | 1660                                              | 187                                               | 187     | 16,7                            | 176                                               | 273                                               | 42      | 527  | 820            |
| 371  | 1610                            | 1830                                              | 188                                               | 188     | 18,7                            | 196                                               | 304                                               | 42,3    | 699  | 923            |
| 411  | 1770                            | 2020                                              | 190                                               | 190     | 20,9                            | 218                                               | 339                                               | 42,8    | 921  | 1040           |
| 458  | 1960                            | 2230                                              | 191                                               | 191     | 23,5                            | 243                                               | 379                                               | 43,3    | 1220 | 1180           |
| 475  | 1800                            | 2060                                              | 213                                               | 213     | 20                              | 192                                               | 300                                               | 43,8    | 527  | 1330           |
| 553  | 2080                            | 2370                                              | 217                                               | 217     | 23,9                            | 228                                               | 356                                               | 45      | 772  | 1600           |
| 616  | 2300                            | 2620                                              | 218                                               | 218     | 27                              | 257                                               | 400                                               | 45,7    | 1030 | 1820           |
| 688  | 2480                            | 2830                                              | 219                                               | 219     | 29,4                            | 279                                               | 435                                               | 46      | 1280 | 1990           |
| 762  | 2800                            | 3200                                              | 221                                               | 221     | 33,9                            | 320                                               | 500                                               | 46,6    | 1810 | 2320           |



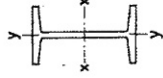
**I-sections  
(taper flange)**  
Dimensions and properties

| Designation    | m    | h     | b     | t <sub>w</sub> | t <sub>f</sub> | r <sub>1</sub> | r <sub>2</sub> | h <sub>w</sub> | β   | A                               |
|----------------|------|-------|-------|----------------|----------------|----------------|----------------|----------------|-----|---------------------------------|
| mm x mm x kg/m | kg/m | mm    | mm    | mm             | mm             | mm             | mm             | mm             | deg | 10 <sup>3</sup> mm <sup>2</sup> |
| 127 x 76 x 13  | 13,4 | 127   | 76,2  | 4,5            | 7,6            | 7,9            | 2,4            | 96             | 95  | 1,70                            |
| 152 x 89 x 17  | 17,1 | 152,4 | 88,9  | 4,9            | 8,3            | 7,9            | 2,4            | 120            | 95  | 2,18                            |
| 178 x 102 x 22 | 21,4 | 177,8 | 101,6 | 5,3            | 9              | 9,4            | 3,2            | 141            | 95  | 2,73                            |
| 203 x 102 x 25 | 25,3 | 203,2 | 101,6 | 5,8            | 10,4           | 9,4            | 3,2            | 164            | 95  | 3,23                            |
| 203 x 152 x 52 | 52,1 | 203   | 152   | 8,9            | 16,5           | 15,5           | 7,6            | 139            | 98  | 6,64                            |



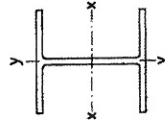
**H-sections (piles)  
(parallel flange)**  
Dimensions and properties

| Designation    | m    | h     | b     | t <sub>w</sub> | t <sub>f</sub> | r <sub>1</sub> | h <sub>w</sub> | A                               |
|----------------|------|-------|-------|----------------|----------------|----------------|----------------|---------------------------------|
| mm x mm x kg/m | kg/m | mm    | mm    | mm             | mm             | mm             | mm             | 10 <sup>3</sup> mm <sup>2</sup> |
| 203 x 203 x 54 | 53,5 | 203,9 | 207,2 | 11,3           | 11,3           | 10,2           | 161            | 6,82                            |
| 254 x 254 x 63 | 62,5 | 246,9 | 256,0 | 10,6           | 10,6           | 12,7           | 200            | 7,96                            |
| 85             | 84,7 | 254,3 | 259,7 | 14,3           | 14,3           | 12,7           | 200            | 10,8                            |
| 305 x 305 x 79 | 79,0 | 299,2 | 306,0 | 11,1           | 11,1           | 15,2           | 247            | 10,1                            |
| 110            | 110  | 307,9 | 310,3 | 15,4           | 15,4           | 15,2           | 247            | 14,0                            |
| 126            | 127  | 312,4 | 312,5 | 17,7           | 17,7           | 15,2           | 247            | 16,2                            |



**I-sections  
(taper flange)**  
Dimensions and properties

| About x-x                       |                                 |                                 |      | About y-y                       |                                 |                                 |      | J                               | C <sub>w</sub>                  |
|---------------------------------|---------------------------------|---------------------------------|------|---------------------------------|---------------------------------|---------------------------------|------|---------------------------------|---------------------------------|
| l                               | Z <sub>e</sub>                  | Z <sub>pl</sub>                 | r    | I                               | Z <sub>e</sub>                  | Z <sub>pl</sub>                 | r    |                                 |                                 |
| 10 <sup>5</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>3</sup> mm <sup>3</sup> | mm   | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>3</sup> mm <sup>3</sup> | mm   | 10 <sup>3</sup> mm <sup>4</sup> | 10 <sup>6</sup> mm <sup>6</sup> |
| 4,76                            | 74,9                            | 85,2                            | 52,9 | ,502                            | 13,2                            | 21,3                            | 17,2 | 37,6                            | 1,79                            |
| 8,84                            | 116                             | 131                             | 63,7 | ,865                            | 19,5                            | 31,5                            | 19,9 | 53,9                            | 4,49                            |
| 15,1                            | 170                             | 192                             | 74,4 | 1,38                            | 27,3                            | 44,2                            | 22,5 | 81,5                            | 9,86                            |
| 23                              | 226                             | 257                             | 84,4 | 1,63                            | 32,1                            | 51,9                            | 22,5 | 117                             | 15,2                            |
| 47,8                            | 471                             | 539                             | 84,8 | 8,10                            | 107                             | 175                             | 34,9 | 667                             | 70,4                            |



**H-sections (piles)  
(parallel flange)**  
Dimensions and properties

| About x-x                       |                                 |                                 |      | About y-y                       |                                 |                                 |      | J                               | C <sub>w</sub>                  |
|---------------------------------|---------------------------------|---------------------------------|------|---------------------------------|---------------------------------|---------------------------------|------|---------------------------------|---------------------------------|
| l                               | Z <sub>e</sub>                  | Z <sub>pl</sub>                 | r    | I                               | Z <sub>e</sub>                  | Z <sub>pl</sub>                 | r    |                                 |                                 |
| 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>3</sup> mm <sup>3</sup> | mm   | 10 <sup>6</sup> mm <sup>4</sup> | 10 <sup>3</sup> mm <sup>3</sup> | 10 <sup>3</sup> mm <sup>3</sup> | mm   | 10 <sup>3</sup> mm <sup>4</sup> | 10 <sup>6</sup> mm <sup>6</sup> |
| 49,8                            | 488                             | 552                             | 85,4 | 16,8                            | 162                             | 249                             | 49,6 | 345                             | 156                             |
| 87,6                            | 710                             | 791                             | 105  | 29,7                            | 232                             | 355                             | 61,1 | 367                             | 414                             |
| 122                             | 963                             | 1 090                           | 107  | 41,8                            | 322                             | 495                             | 62,2 | 873                             | 602                             |
| 164                             | 1 100                           | 1 220                           | 128  | 53,1                            | 347                             | 530                             | 72,6 | 521                             | 1 100                           |
| 236                             | 1 530                           | 1 720                           | 130  | 76,8                            | 495                             | 760                             | 74,0 | 1 330                           | 1 640                           |
| 275                             | 1 760                           | 2 000                           | 131  | 90,2                            | 577                             | 888                             | 74,7 | 1 990                           | 1 960                           |