

# Guideline Floors for use with VNA Trucks

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# 1 Scope

This guideline specifies the requirements for dimensional regularity of finished floors inside of buildings used by guided VNA Industrial Trucks and other Industrial Trucks travelling with elevated loads (see EN 1726-2/ prEN ISO/DIS 3691-3) and/or operator positions inside very narrow aisles or in close proximity to racking in wide aisles.

# 2 List of references

This guideline incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this guideline only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

**EN 1726-2:**

Safety of industrial trucks – Self-propelled trucks up to and including 10.000 kg capacity and tractors with a drawbar pull up to and including 20.000 N – Part 2: Additional requirements for trucks with elevating operator position and trucks specifically designed to travel with elevated loads

**prEN ISO/DIS 3691-3:**

Industrial trucks – Safety requirements and verification – Part 3: Additional requirements for trucks with elevating operator position and trucks specifically designed to travel with elevated loads

## 3 Definitions

### 3.1 Finished floor

surface to be used by industrial trucks

### 3.2 Very narrow aisle (VNA)

aisle between racks for use of industrial trucks having minimum clearance of 90mm to the rack or the load

### 3.3 Section

any 2 m measuring length of a wheel track within the VNA

### 3.4 Transfer aisle

any area where the industrial truck transfers between stacking areas

### 3.5 Elevational difference

difference in height between two points. The points can be fixed at prescribed distances or they can be moving pairs of points at prescribed distances apart

### 3.6 Change of elevational difference

the change in the elevational difference of two moving points, at a prescribed distance apart, in response to a movement of the two points over a prescribed distance.

### 3.7 Datum

a point used as a reference for levelling

### 3.8 Levelness

surface characteristics over a larger area, typically a 3 m grid, and to datum

### 3.9 Flatness

surface characteristics over defined distances

### 3.10 Waviness

repeating surface characteristics over a short distance

## 4 Requirements

The requirements for the floor surface i.e. flat, level and smooth shall be such that the optimal use of the VNA-Industrial-truck is not compromised.

Note: The following must be considered to ensure optimal operation of VNA industrial trucks however specific criteria are not specified in this guideline

- floor surface with regard to traction performance
- floor mechanical resistance and durability
- criteria for the interface between drive wheel, load wheels and floor

### 4.1 Floors

#### 4.1.1 General

Floors for Industrial Trucks covered by this guideline shall be flat and level.

With respect to non dimensional requirements, the floor quality shall meet the quality levels appropriate for use with industrial trucks.

#### 4.1.2 Floor deflection and interruption

The finished floor shall not deflect plastically.

Shaft, channels, man-holes and similar interruptions of the floor surface shall be positioned with a minimum distance of 200 mm from wheel tracks and rack foot pads unless suitable load bearing devices are used.

## 4.2 Floor Tolerances

### 4.2.1 Limiting values of properties

The limiting values of properties shall not exceed those given in Annex A, Table A.1 - A.3

### 4.2.2 Limiting values for flatness along the tracks in very narrow aisles

The limiting values shall not exceed those given in Annex A, Table A.1 and A.2

### 4.2.3 Limiting values of Waviness Numbers Fx

Tolerances for floors used by Industrial Trucks covered by this guideline and their limiting values shall be manufactured, checked and measured by using Waviness Numbers.

The values of Fx Waviness Numbers for all wheel tracks shall exceed the limiting values.

See Annex A for calculation, measurement methods and limiting values Table A.3

### 4.2.4 Limiting values for levelness

All points on any 3 m grid shall be within +/- 15 mm of the datum, where the datum is across the whole of the truck operating area.



## Annex A (normative)

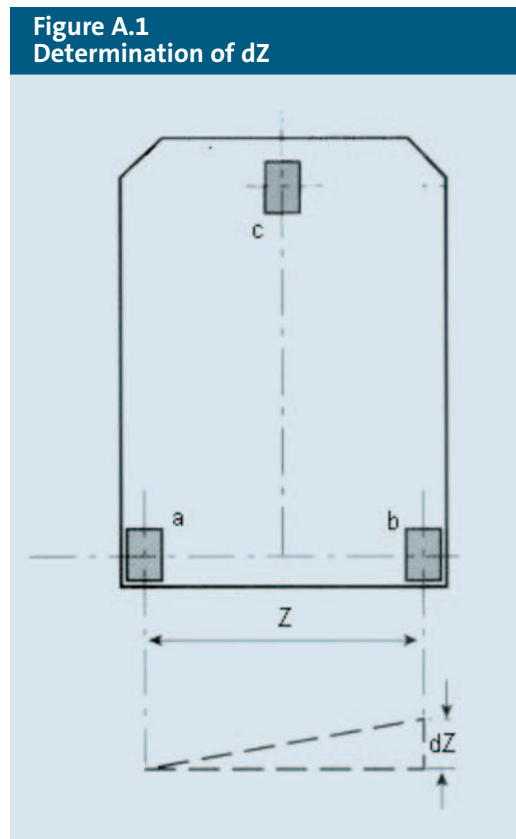
### A.1. Floor Flatness

#### A.1.1 Property Z and $Z_{\text{SLOPE}}$

Z is the dimension between the centres of truck load wheels (a, b) in m and  $Z_{\text{SLOPE}}$  is the permitted cross aisle slope between the centres of truck load wheels (a,b) in mm/m.

#### A.1.2 Property dZ

Property dZ is the elevational difference between the centres of truck load wheels (a, b) and dZ is determined as shown in figure A.1.



### A.1.3 Limiting values of properties

The values of properties shall not exceed the values given in Table A.1.

Top beam level (m)	$Z_{\text{SLOPE}}$ (mm/m)	$dz = Z \times Z_{\text{slope}}$
15	1,0	$Z \times 1,0$ mm/m
10	1,5	$Z \times 1,5$ mm/m
up to 6	2,0	$Z \times 2,0$ mm/m

Note: For beam levels >6m, interpolation is required as illustrated in figure B.1

**Table A.1**

Limiting values of  $Z_{\text{SLOPE}}$

### A.1.4 Limiting values for flatness along the tracks in very narrow aisles

The values shall not exceed the values given in Table A.2.

The measurement shall be done as described in DIN 18202

Distance between measurement l	Gap under straight line t
1 m	2 mm
2 m	3 mm
3 m	4 mm
4 m	5 mm

**Table A.2**

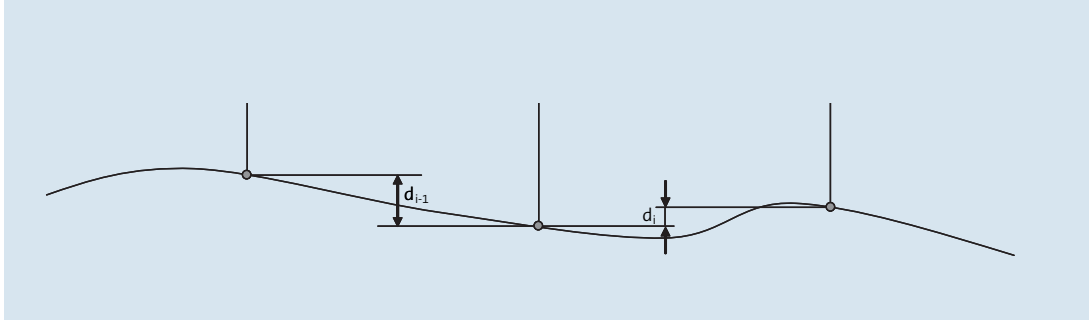
Limiting values along the tracks

### A.1.5 Elevation difference $d_i$

$d_i$  is the elevation difference between adjacent reading points.

$d_i$  is determined in mm as shown in figure A.2.

**Figure A.2**  
Determination of  $d_i$



### A.1.6 Profile curvature $q_i$

$q_i$  is the profile curvature between reading points. A positive  $q_i$  value will denote a trough, while a negative  $q_i$  value will denote a crest.

$q_i$  is determined in mm as follows:

$$q_i = d_i - d_{i-1}$$

### A.1.7 Waviness Number $F_x$

$F_x$  values estimate the floor's characteristic waviness, especially those of the wheel tracks. The  $F_x$  value of a wheel track is determined as follows:

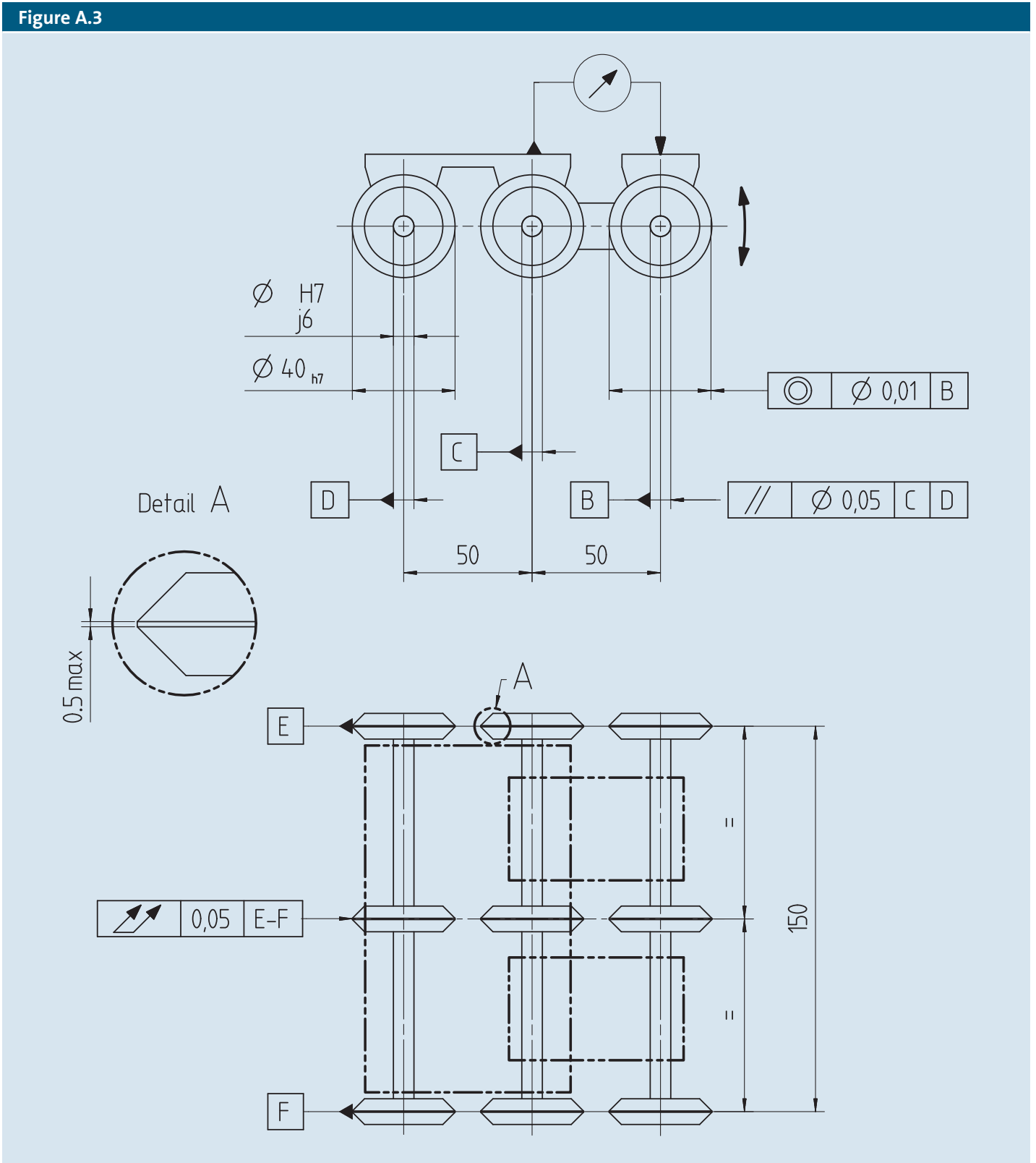
#### A.1.7.1 Measurement

Measurement starts at first upright. Divide the aisle along the track into sections of 2 m. Within these sections, subdivide each line of wheel track into 50 mm long intervals. This results in 40 intervals in each section. The points marking the ends of these intervals are the 40 reading points. For each wheel track, measure and record in sequence the difference in elevation  $d_i$  (in mm) between adjacent reading points along the wheel track (see figure A.1). This results to 39  $d_i$  values.

Measurement device shall meet the requirements and tolerances as described in figure A.3.

Other measurement methods are possible only if the results are demonstrably identical.

Figure A.3



Recommended layout for the measurement device of elevation difference  $d_i$   
 The named tolerances are valid for all axes and rolls. Rolls made of steel.

**A.1.7.2 Calculation – profile curvature**

Calculate the profile curvatures  $q_i$  between all reading points as follows:

$$q_i = d_i - d_{i-1}$$

This results in 38  $q_i$  values.

Annotation: These  $q_i$  values do not represent a difference in height any longer. They should be interpreted as a curvature – see A.1.6.

**A.1.7.3 Calculation – arithmetic mean  $q_i$** 

Add all 38  $q_i$  values as follows:

$$\sum_{i=2}^{39} q_i = q_2 + q_3 + q_4 + \dots + q_{39}$$

Divide this sum by 38 to obtain the mean value of the  $q_i$  values as follows:

$$\bar{q}_i = \frac{\sum_{i=2}^{39} q_i}{38}$$

**A.1.7.4 Calculation – standard deviation  $S_q$** 

Calculate the variance  $V_q$  of the  $q_i$  values as follows:

$$V_q = \frac{\sum_{i=2}^{39} q_i^2 - \bar{q}_i \sum_{i=2}^{39} q_i}{37}$$

Take the square root of the variance  $V_q$  to obtain the standard deviation  $S_q$  of the  $q_i$  values as follows:

$$S_q = \sqrt{V_q}$$

**A.1.7.5 Calculation – Fx Waviness Number**

Estimate the Fx Waviness Number for each wheel track as follows:

$$F_x = \frac{115,8454 \text{ mm}}{(3 \cdot S_q + |\bar{q}_i|)}$$

Note: The factor of 115,8454 mm represents a calibration factor.

#### A.1.7.6 Calculation – $F_{x,avg}$ Waviness Number for continuous measurement method

It is possible to achieve an improved repeat accuracy by means of a continuous measurement along the aisle. If such a continuous measurement is chosen, the following requirements apply:

The measurement as described above is conducted in steps, 2 mm apart from each other. Over a distance of 50 mm, this procedure provides  $n = 25$  different sets of reading points as described in A. 1.7.1, resulting in 25  $F_{x,n}$  results according to A. 1.7.5. The final value  $F_{x,avg}$  is calculated by averaging these 25  $F_{x,n}$  values.

$$F_{x,avg} = \frac{\sum_{n=1}^{25} F_{x,n}}{25}$$

#### A.1.7.7 Calculation – Calculation Sheet

A sample sheet for conduction of the calculation described above is available on the VDMA Website, [www.vdma.org/ilog](http://www.vdma.org/ilog).

#### A.1.8 Limiting values of Waviness Numbers $F_x$ or $F_{x,avg}$

The values of  $F_x$  or  $F_{x,avg}$  Waviness Numbers for all wheel tracks and all 2 m sections shall exceed the values given in Table A.3.

Top beam level (m)	$F_x$ or $F_{x,avg}$
15	525
10	400
up to 6	300

Note: For beam levels >6m, interpolation is required as illustrated in figure B.3

**Table A.3**

Limiting values of  $F_x$  or  $F_{x,avg}$

## Annex B (informative) (for the user)

### B.1. Example

#### B.1.1 Calculation

Parameters:

Top beam level = 8 m

Track width  $Z = 1,5$  m

Requirements:

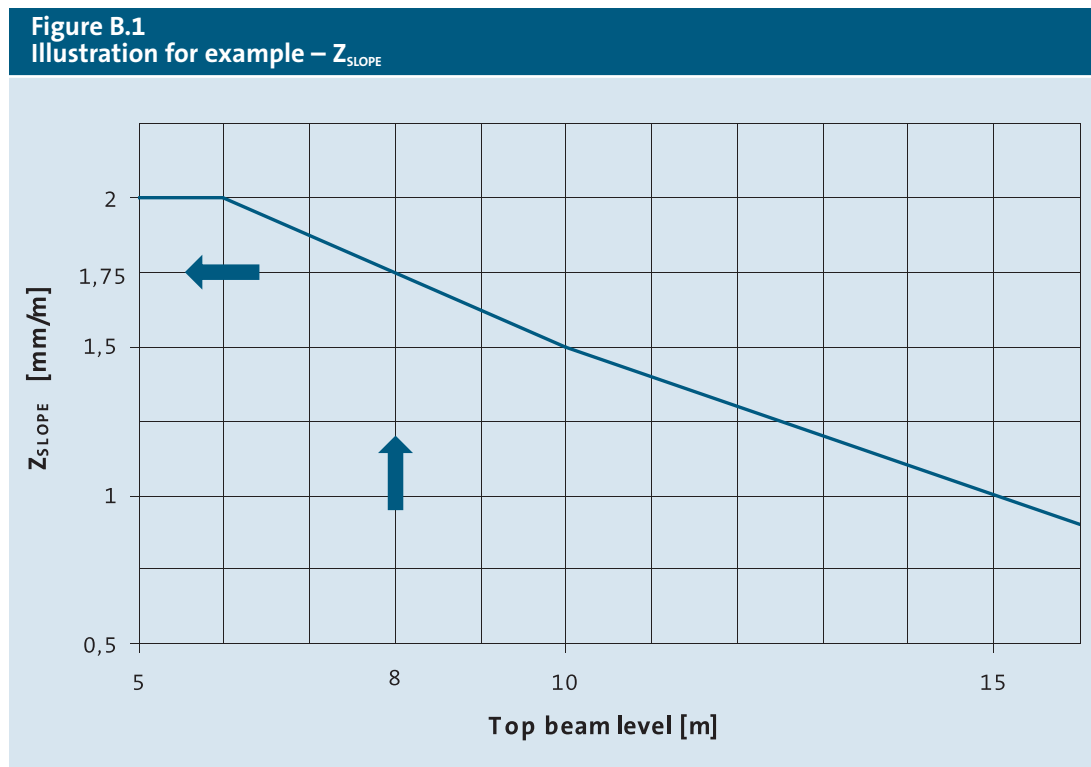
A.1.3 Table A.1:  $Z_{SLOPE} = 1,75$  mm/m and  
 $dZ = 2,625$  mm

A.1.4 Table A.2: Gap below requirement  
for all distances listed in  
the table

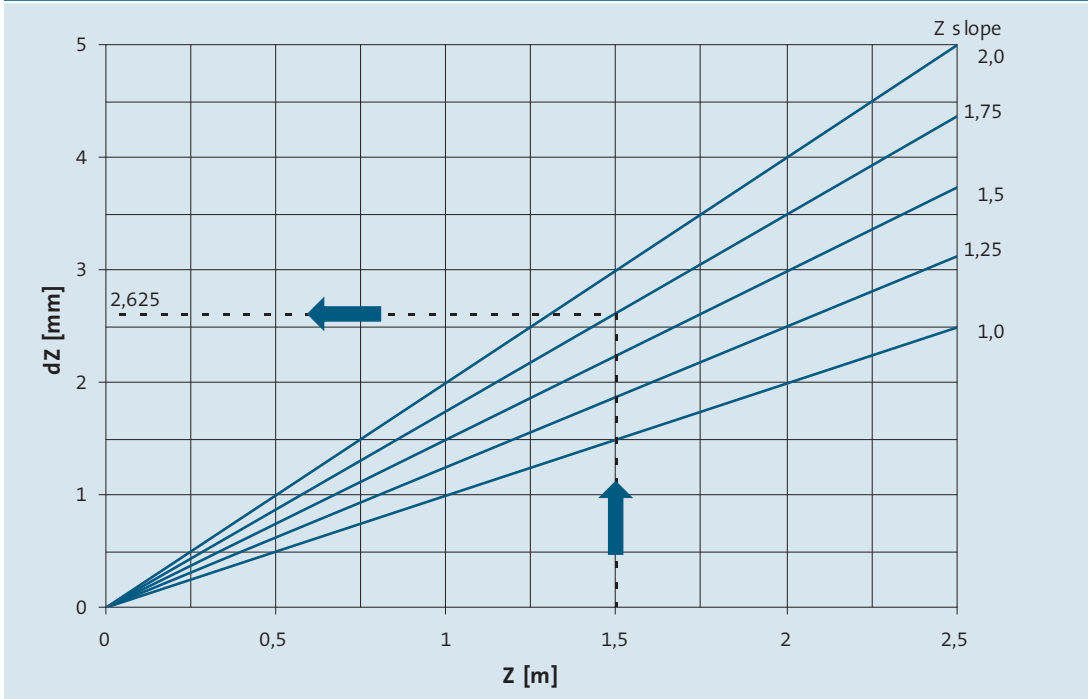
A.1.8 Table A.3:  $F_x \geq 350$

#### B.1.2 Graph

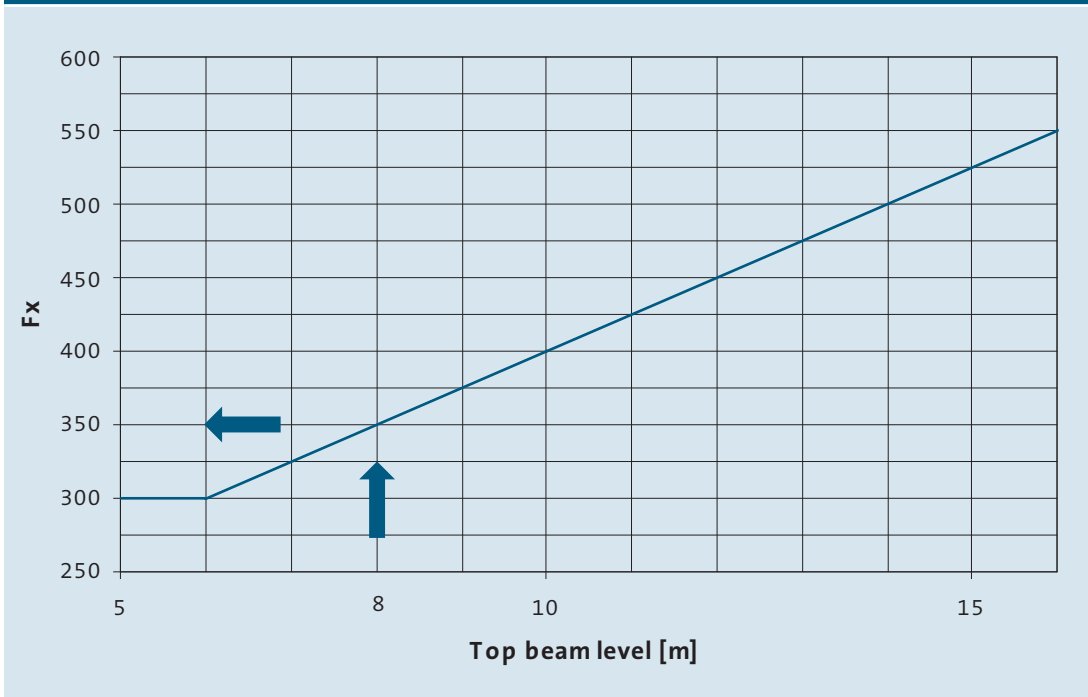
Figures B.1 to B.3 illustrate the results of  
A.1.3, Table A.1 and A.1.4, Table A.2 and  
A.1.8, Table A.3 for above calculation example.



**Figure B.2**  
Illustration for example – dZ



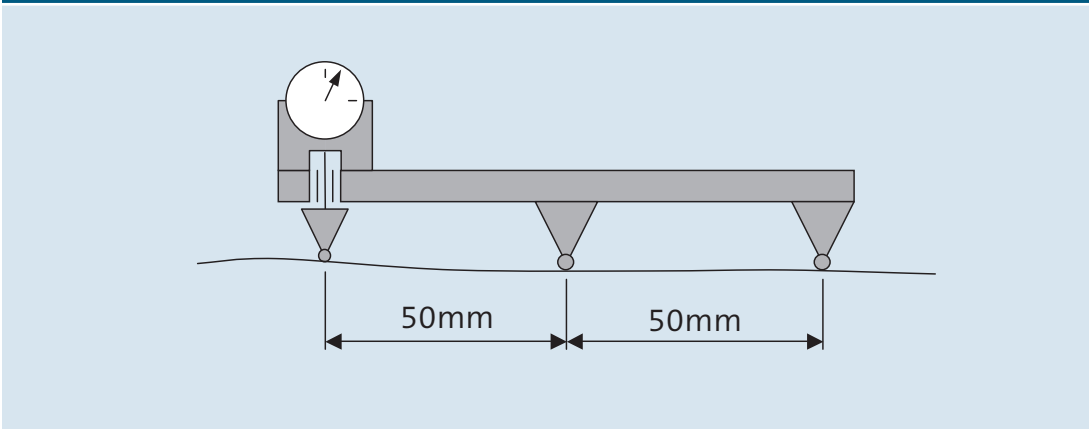
**Figure B.3**  
Illustration for example – Fx





**B.2. The main principle for the measurement of the curvature of a profile**

**Figure B.4**  
The main principle for the measurement of the curvature of a profile



**Figure B.5**  
The main principle for a simple measurement device (Curvature gauge)

