8. Gerber beams[1]

Introduction

hinge-attached beam – a beam made up of simple beams joined flexibly by hinges
We determine the cross-section forces of the hinge-attached beams by dividing them into simple ones.
Note: Each cut across a hinge results in two unknown forces, usually one vertical and one horizontal.

Tip: Serious errors result from lack of unknown forces at a slit hinge.

Gerber beam – a beam made up of simple beams, arranged collinearly and joined one-by-one by hinges
Note: Horizontal translation of the Gerber's beam should be blocked only once, otherwise the beam is redundant.
GR: The axial force depends on horizontal component of loading only and can be determined in the first stage of calculation, just after the calculation of the horizontal reaction.
GR: Horizontal components of loadings are irrelevant to bending moment and shear force calculation and may be neglected in the further calculation.
Instead of using the hinges' equations, we rearrange the simple beams in such a way that each beam is properly supported. In this way we determine the reaction solution order: we start from the highest beams and finish with the lowest.
Having all simple beams solved separately, we put together the cross-section forces diagrams.
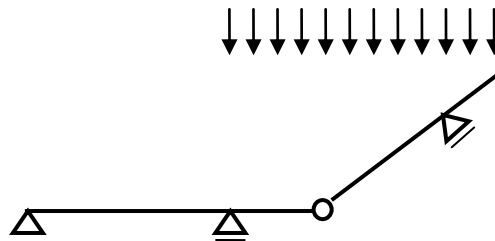
Examples

Hinged beam – "nothing new"

Fig. 8.1 Articulated beam

To determine the articulated beams we proceed in the usual way, decomposing the structure into simple beams. The beams are joined by hinges. Replacing each hinge by the set of internal forces we get the static schemes ready to use for calculations, Fig. 8.2.
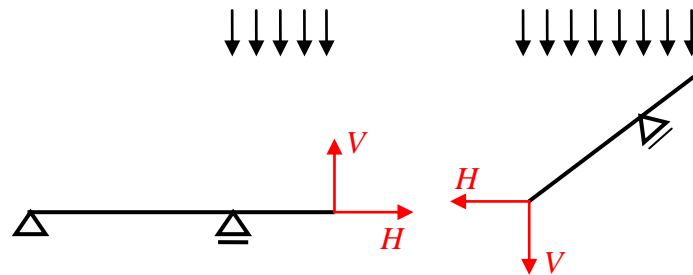

Fig. 8.2 Decomposition into simple beams

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[1] patented in 1886 by Heinrich Gerber

Gerber beam

When the axes of the simple beams are collinear and the horizontal translation is taken away only once, such beam is called the cantilever beam or Gerber beam. The cross-section forces of the beam may be determined by a simpler method, not using the general way.

Because there is only one horizontal unknown of constraints, we determine its value and make the entire diagram of axial force, using only horizontal components of the loads.

We "forget" horizontal loads' components and we consider the vertical components only in the sequel. Not knowing how to begin with the most important part of loading, we construct an equivalent static scheme. It consists in ordering the simple beams in a sequence on the basis of the constraints. The highest beams are calculated first, next the beams of second order and so on.
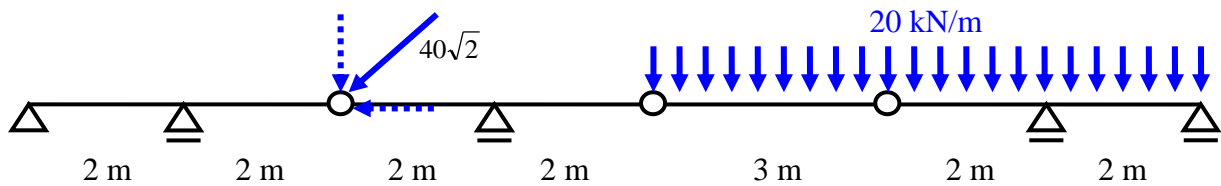
Example

Fig. 8.3 Cantilever (Gerber) beam

Solution:

This is so-called Gerber beam (cantilever beam) because of the axis in the shape of straight line and only one pin-support, all others being the rollers. We decompose the loads into horizontal and vertical, acting separately. We determine the horizontal reaction, horizontal cross-section force and construct the diagram of the axial force, Fig. 8.4.
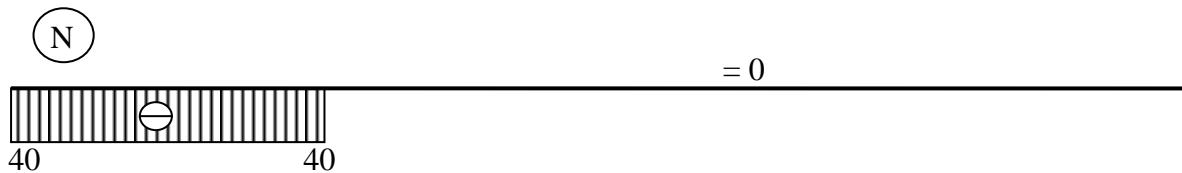

Fig. 8.4 Diagram of axial force

In the sequel we neglect all horizontal compounds of the loads, which produce neither bending moments nor shear forces. Instead of finding vertical reactions from static balance equations, we construct an equivalent static scheme, placing consecutive beams, determined by the hinges, in position assuring stability (now the horizontal translation is excluded from our considerations). If the entire beam is stable, the procedure ends by last beam being stable, too, Fig. 8.5.
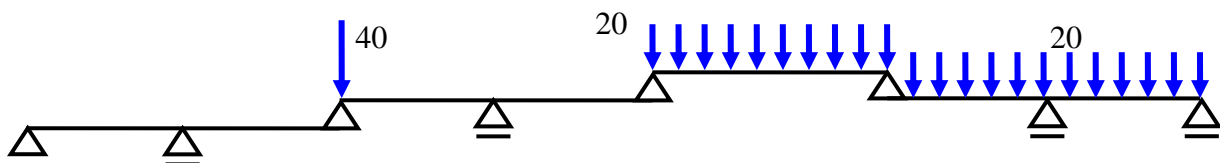

Fig. 8.5 Equivalent static scheme

We apply the loads to the upper or lower beam, but only once. The solution can be made starting from the most upper beams up to the lowest, in turn, Fig. 8.6.
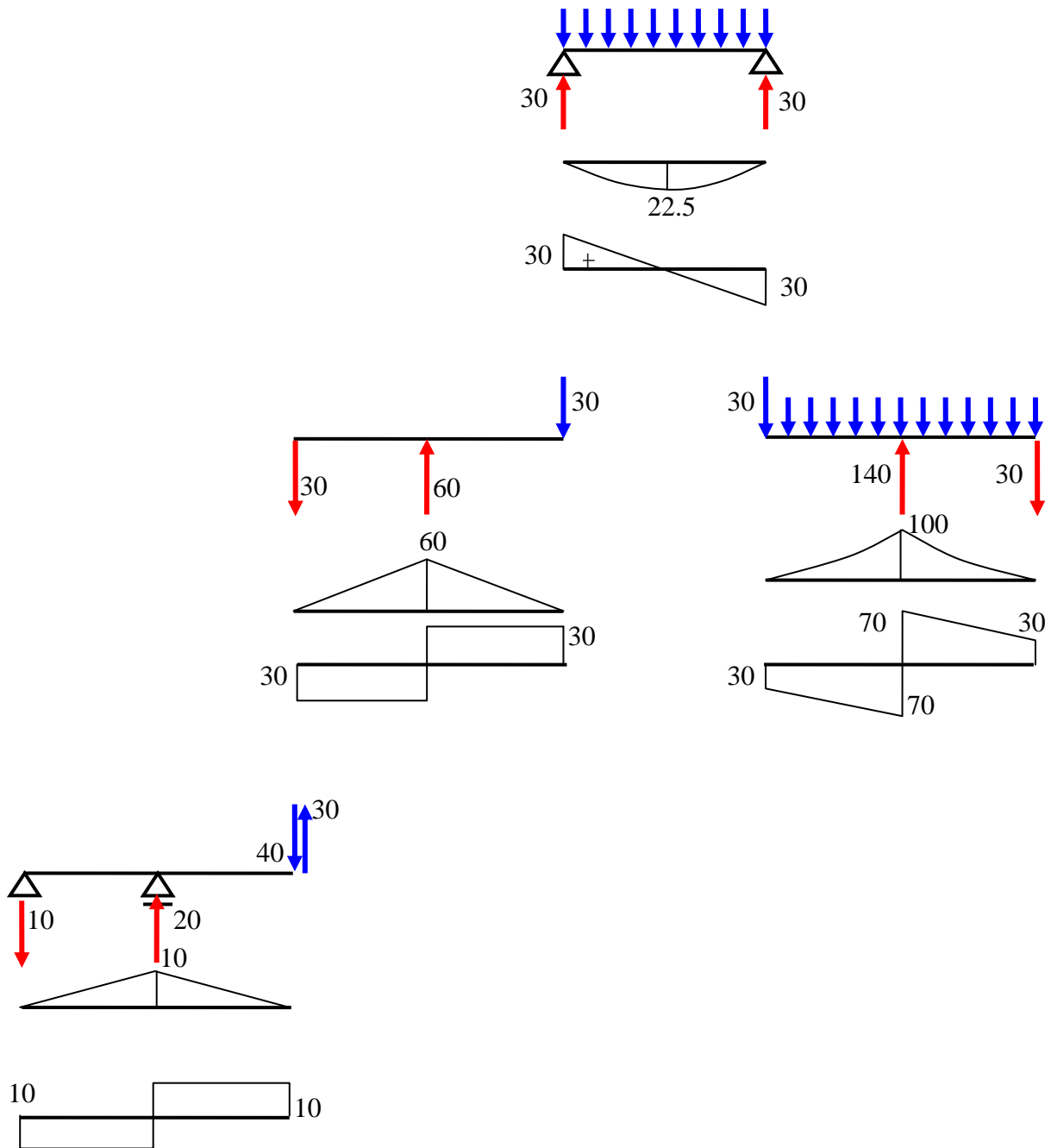
Fig. 8.6 Simple beams sequence
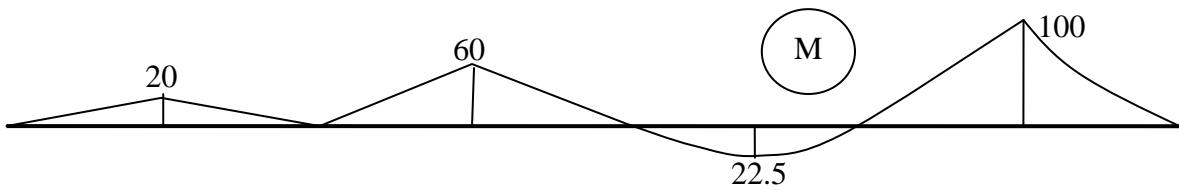
Collective diagrams:
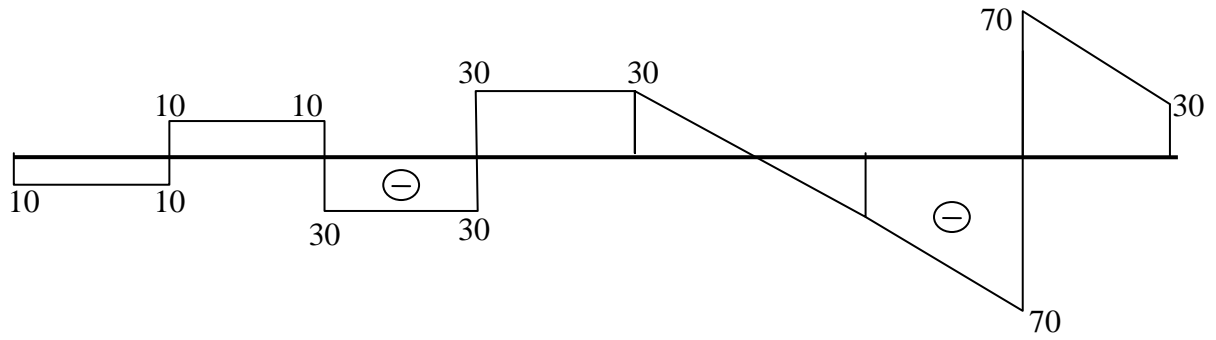

Fig. 8.7 Bending moments

Fig. 8.8 Shear forces of the cantilever beam

Workshop theme

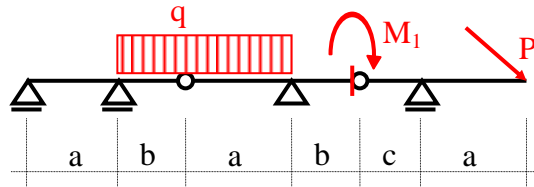Construct the diagrams of the cross-section forces through the equivalent scheme and the simple beams.

Fig. 8.9 Cantilever beam

Input data:

$a = \ldots\ldots$ m $(2 \div 3$ m$)$

$b = \ldots\ldots$ m $(1.5 \div 2.5$ m$)$

$c = \ldots\ldots$ m $(1 \div 2$ m$)$

$P = \ldots\ldots$ kN $(20 \div 50$ kN$)$

$M_1 = \ldots\ldots$ kNm $(10 \div 40$ kNm$)$

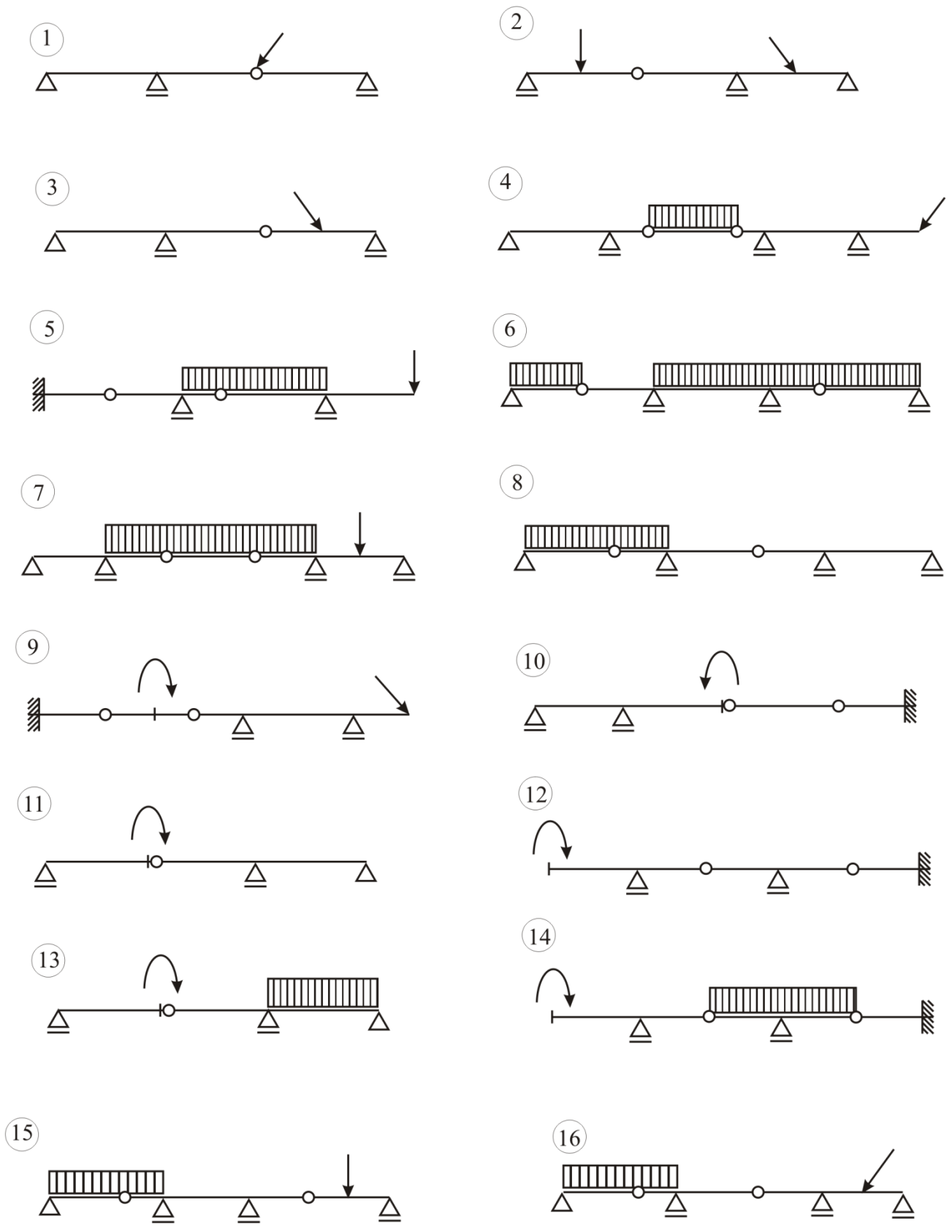$q = \ldots\ldots$ kN/m $(15 \div 55$ kN/m$)$

Review problems

Fig. 8.10 Review problems

Addendum

Tip: Keep in mind that the hinge is not the characteristic point (for functions of cross-section forces). Simply, the bending moment zeroes at a hinge. Nothing more, but it is pretty much.

[2]The Gerber beam idea consists of introducing hinges in a continuous beam to make it isostatic, so that it becomes a series of simply supported beams extended at their ends by cantilevers in alternate spans that are linked to each other by beams supported on the cantilever ends. This system gives the advantages of the continuous beam and of the isostatic structure:

– the continuous beam because the bending moment distribution alternate positively and negatively at supports and span centres, the same as in the beam and, therefore, its maximum values are less than in the supported beam;
– the isostatic structure, because its stresses are not affected by deformations of the ground where they are resisted, which is a fundamental and sometimes determining condition when the foundation ground is not good.

The Gerber beam has other advantages over the continuous type:

– the main supports can be fixed and hinges made movable, with deformation being accumulated in them due to the structure's temperature
– determining its member force distribution analytically is much easier than in the continuous beam precisely due to its isostatism.

Glossary

hinge-attached beam – belka przegubowa
continuous beam – belka ciągła (na wielu podporach)
Gerber beam, cantilever beam – belka przegubowa, belka gerberowska
isostatic – statycznie wyznaczalny
isostatism – statyczna wyznaczalność
statically indeterminate; redundant – statycznie niewyznaczalny

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[2] excerpt from: *Bridge engineering: a global perspective*, by Leonardo Fernandez Troyano, Thomas Telford ed., p. 354