Part 02. Structural System

- Section Active -

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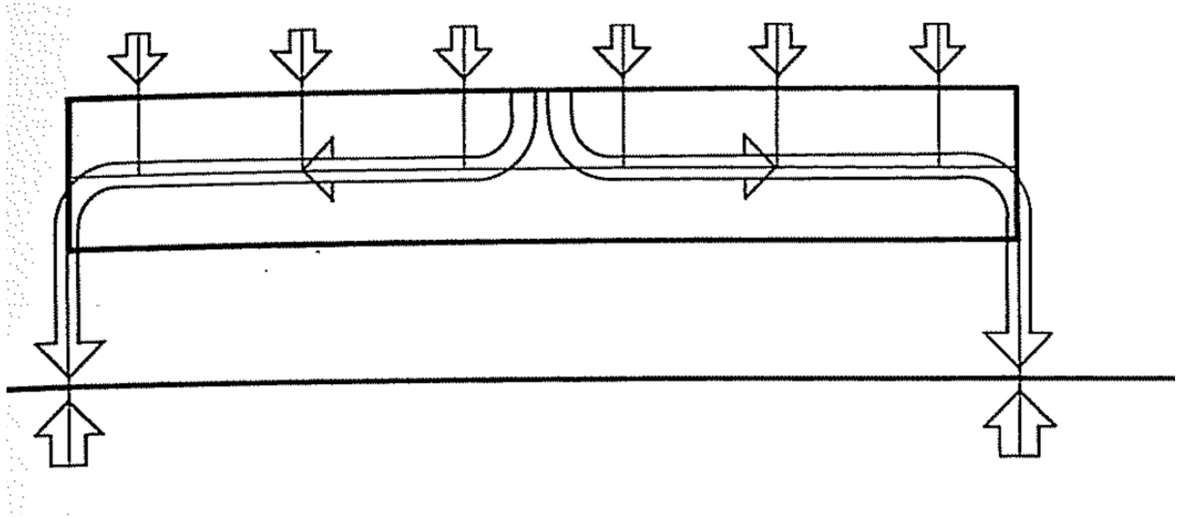
DEFINITION OF SECTION-ACTIVE STRUCTURAL SYSTEM

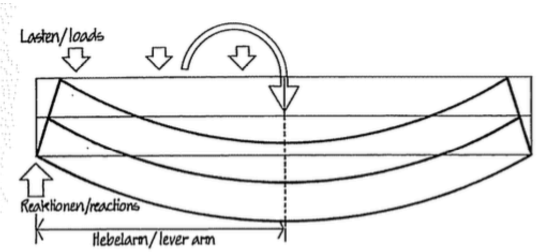
- Beams are straight-line, bending-resistant structural elements that cannot only resist forces that act in the direction of their axis, but by means of sectional stresses can receive also forces perpendicular to their axis and transport them laterally along their axis to the ends. Beams are basic elements of section-active structure systems.
- Because of its capacity to laterally transfer loads and still maintain the horizontal space enclosure that is so convenient for the three-dimensional space seizure, the beam is the structure element most frequently used in building construction.
- The bearing mechanism of section-active structure systems consists of the combined action of compressive and tensile stresses within the beam section in conjunction with shear stresses: bending resistance. Due to bending deflection an internal rotation moment is activated that counterbalances the external rotation moment.
- Section-active structure systems can be live expression of the struggle for equilibrium between internal and external rotation moments.
- As continuous beam, hinged frame, complete frame, multi-panel frame, and multi-story frame the section-active structures have brought to full expression the mechanics of continuity. By means of these systems it is possible to achieve long spans and provide free floor space unencumbered by supports, without having to give up the advantage of rectangular geometry.

▶ System of redirecting forces



external forces are redirected through sectional fabric (section forces)

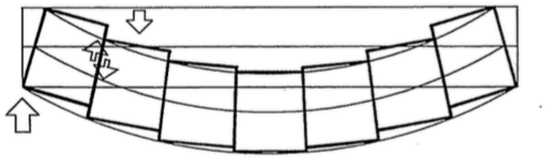
MECHANISM OF BENDING AND BENDING RESISTANCE



Äußeres Drehmoment (Biegung) — external rotational moment (bending)

Die Summe der äußeren Kräfte (Lasten und Reaktionen) bewirkt Drehung der freien Enden (Auflagerpunkte), die zur Krümmung der Längsachse führt: Biegung

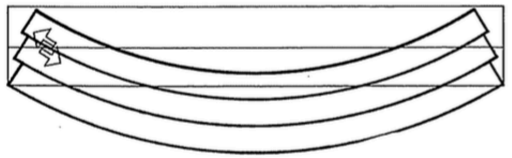
the sum of external forces (loads and reactions) generates a rotation of the free ends (points of support) that causes the longitudinal axis to curve: bending



Querkräfte (vertikale Scherkräfte) — vertical shear

Wegen der Seitendifferenz der Richtungen von Last und Reaktion versuchen die äußeren Kräfte die vertikalen Fasern gegeneinander zu verschieben

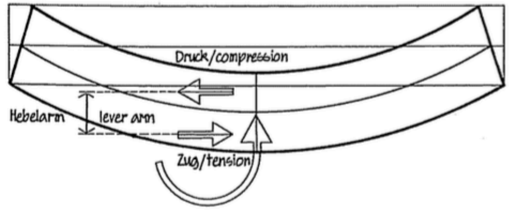
since the directions of load and reaction do not meet, the external forces make vertical fibres tend to slip and introduce vertical shear



Horizontale Scherkräfte — horizontal shear

Die Durchbiegung verursacht Verkürzung der oberen und Verlängerung der unteren Schichten, wodurch die horizontalen Fasern gegeneinander verschoben werden

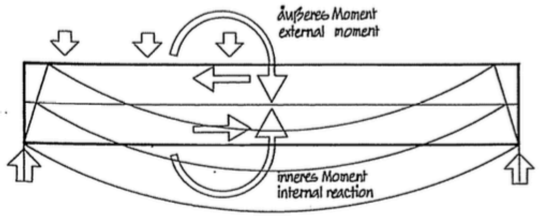
bending deflection causes contraction of the upper layers and expansion of the lower layers. horizontal fibres tend to slip introducing horizontal shear



Inneres Drehmoment (Reaktion) — internal rotational moment (reaction)

Infolge Durchbiegung werden mittels Scherkraftübertragung Zug- und Druckkräfte im Querschnitt aktiviert, die ein inneres Drehmoment bewirken

Due to bending deflection tensile and compressive stresses are generated in the cross section by means of shear. they produce an internal rotation moment

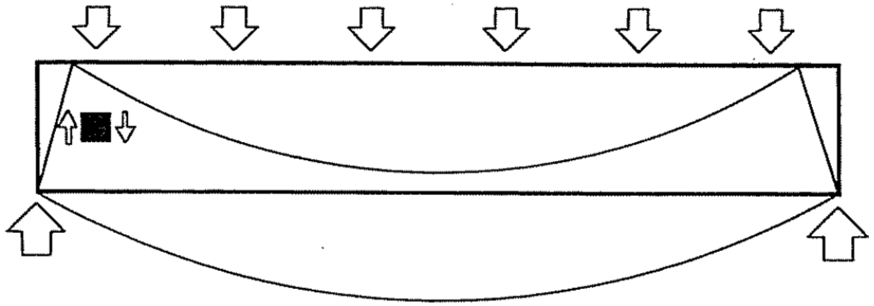


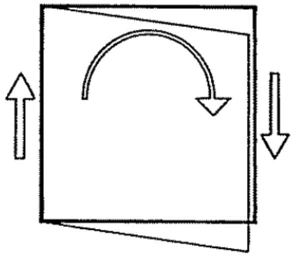
Biegung und Biegewiderstand — bending and bending resistance

Das Drehmoment der äußeren Kräfte bewirkt Durchbiegung bis zu dem Punkt, wo das innere reaktive Drehmoment groß genug geworden ist, um das äußere aufzuhalten.

rotation moment of external forces produces bending deflection until a point is reached where the internal reactive moment has grown big enough to compensate the external moment

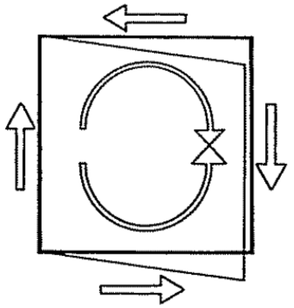
RELATIONSHIP BETWEEN SHEAR, TENSION AND COMPRESSION IN BENDING





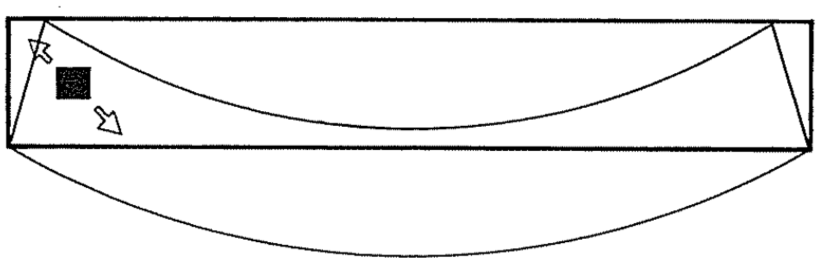
Durch äußere Kräfte werden Querkräfte erzeugt, die die Elemente (Rechteck) eines Trägers zu drehen versuchen und damit Durchbiegung bewirken

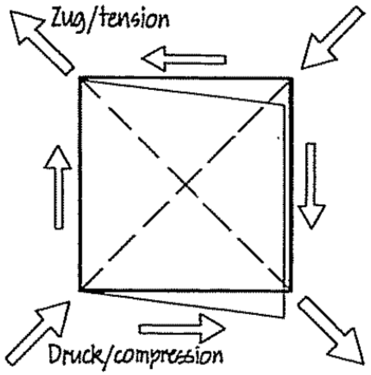
due to external forces vertical shear stresses are generated which tend to rotate the elements (rectangle) of a beam and cause bending deflection



Infolge Durchbiegung werden horizontale Scherkräfte erzeugt, die die Elemente (Rechteck) in umgekehrter Richtung zu drehen versuchen und dadurch Rotationsgleichgewicht herstellen

due to bending deflection horizontal shear stresses are generated which tend to rotate the elements (rectangle) in reverse direction and establish equilibrium in rotation

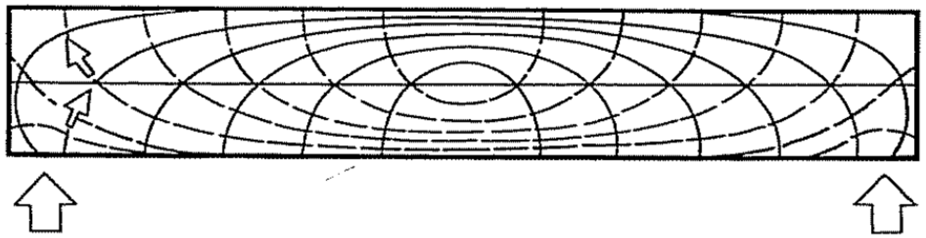


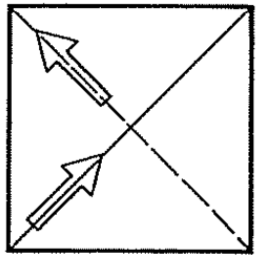


Querkräfte und horizontale Scherkräfte vereinigen sich zu Zug- und Druckkräften, die die Elemente zu Rauten verformen. Der Verformung steht die Festigkeit des Materials entgegen

vertical and horizontal shear stresses combine for both tensile and compressive stresses that give the elements a rhombic shape. this deformation is resisted by the material strength

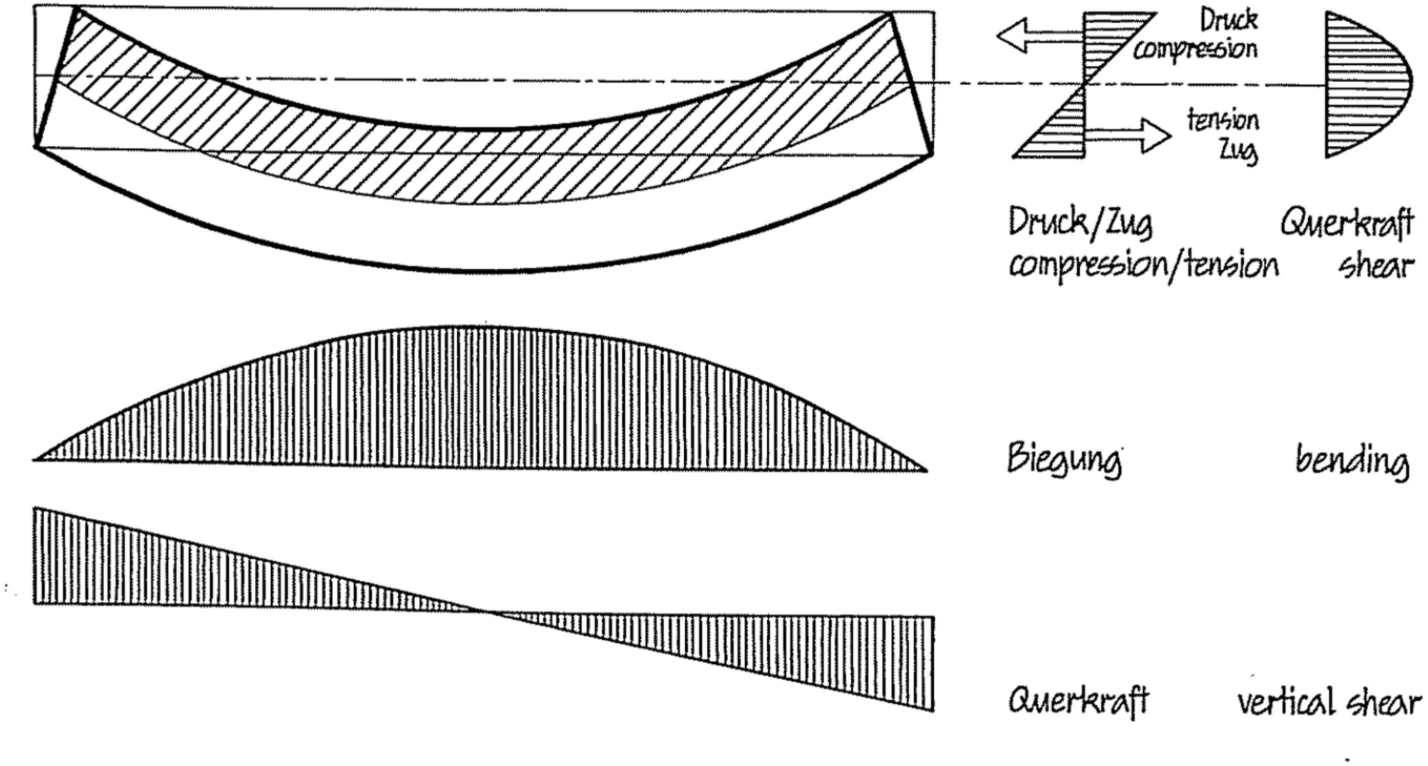
LINES OF PRINCIPAL DIRECTIONS OF STRESS = ISOSTATICS





Spannungsrichtungen im Balken bilden zwei Gruppen, die sich immer rechtwinklig kreuzen: Druckrichtungen haben Stützlinienform, Zuglinien haben Kettenlinienform

stress pattern in beam indicates two sets of stress directions that always intersect at right angles: compressive stress directions assume arch shape, tensile stress directions assume catenary shape



Spannungsverteilung im Trägerquerschnitt
stress distribution across beam section

Biegespannungen sind bei Gleichstreckenlast parabolisch über die Länge des Trägers verteilt, mit max Spannung in Trägermitte.

bending stresses for continuous load are parabolically distributed over length of beam, max stresses occurring in midspan

Querkräfte sind max über den Auflagern und nehmen nach der Mitte zu ab. Sie werden Null in Balkenmitte

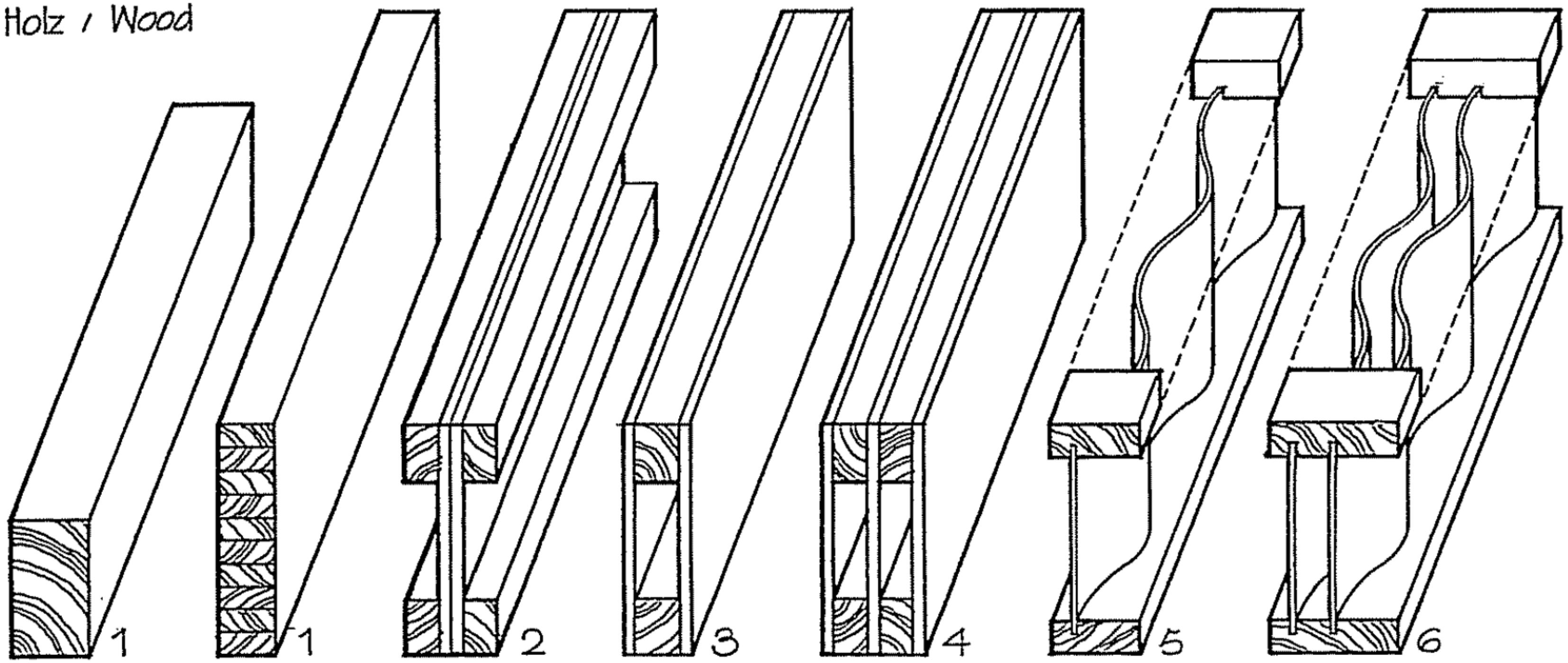
vertical shear stresses are max over supports and decrease toward center, they are zero in midspan

SECTION DESIGN OF SOLID WEB BEAMS (1/2)

Die Wirkungsweise der schnittaktiven Tragsysteme beruht auf Mobilisierung von Schnittkräften. Das heißt, die Tragfunktion dieser Systeme wird durch Aktionen im Querschnitt ausgeübt. Folgerichtig ist hier – im Unterschied zu den anderen Tragwerk-Gattungen – die Ausbildung des Träger-QUERSCHNITTES in Abhängigkeit von Material ein primäres Anliegen des Tragwerk-Entwurfes

The mechanics of section-active structure systems rests upon mobilization of section forces. This will say that the structural function of these systems is performed by actions within the cross section. Consequently, the design of the beam CROSS SECTION, in compliance with the specific material, is – unlike as with other structure families – a primary concern in developing structures

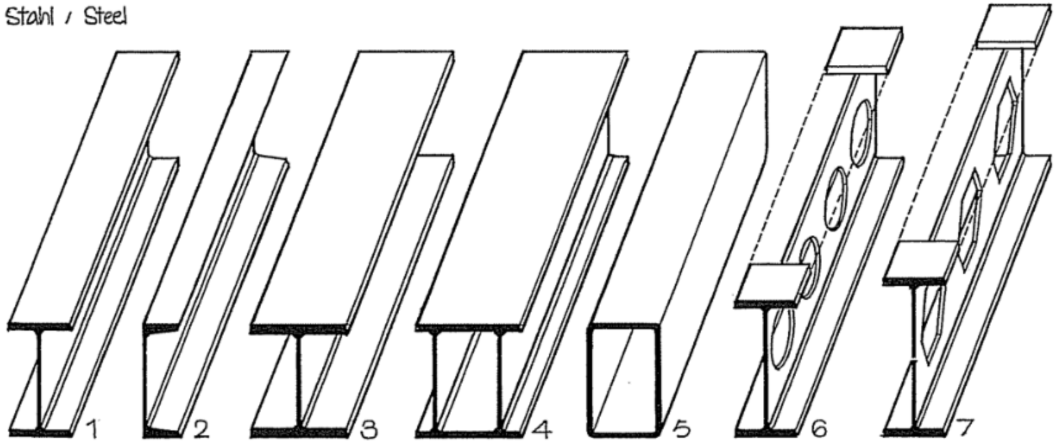
Holz / Wood



1 Rechteck-Träger
2 I-Träger
3 Kasten-Träger
4 Doppelkasten-Träger
5 Wellsteg-Träger
6 Doppelwellsteg-Träger

1 Rectangular beam
2 I-beam
3 Box beam
4 Double-box beam
5 Corrugated web beam
6 Corrug. two-web beam

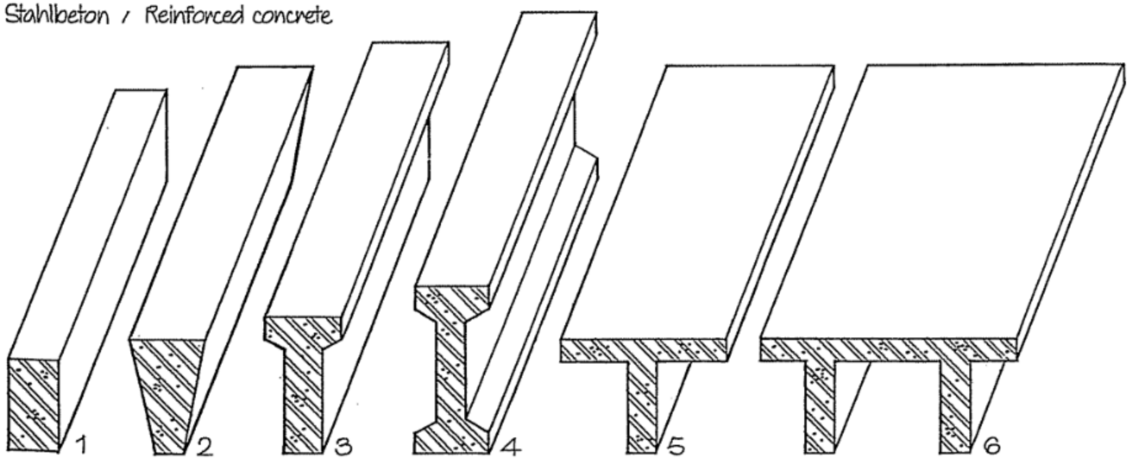
Stahl / Steel



1 I-Träger
2 U-Profil-Träger
3 Breitflansch-Träger
4 Kasten-Träger
5 Hohlprofil-Träger
6 Lochsteg-Träger
7 Waben-Träger

1 I beam
2 Channel (profile) beam
3 Wide flange b., H beam
4 Box beam
5 Hollow section beam
6 Perforated web beam
7 Honeycomb web beam

Stahlbeton / Reinforced concrete



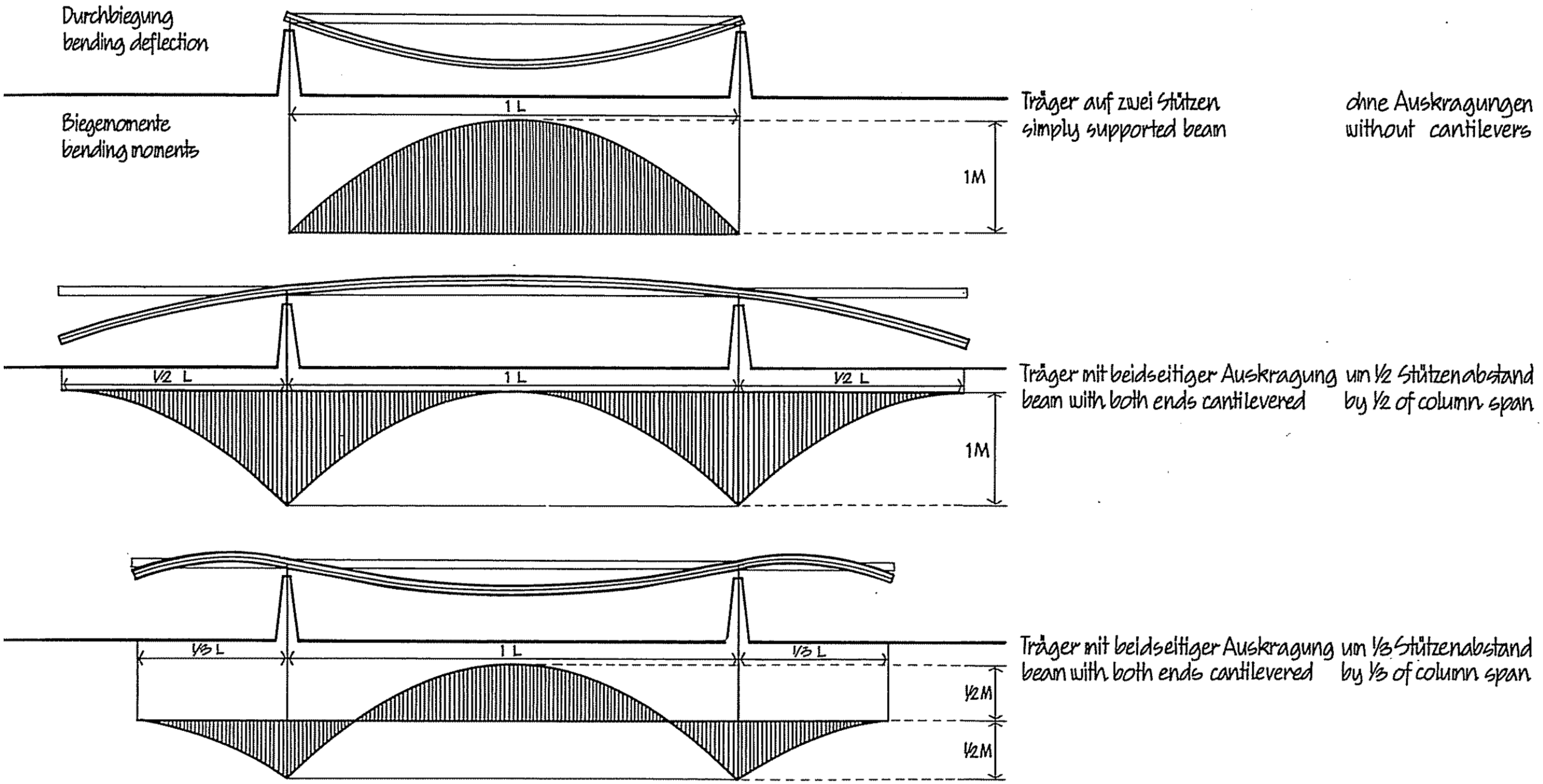
1 Rechteck-Träger
2 Trapez-Träger
3 T-Träger
4 I-Träger
5 Plattenbalken
6 Doppelsteg-Plattenbalken

1 Rectangular beam
2 Trapezoid beam
3 Top-beaded beam
4 I beam
5 T beam
6 Double-T beam

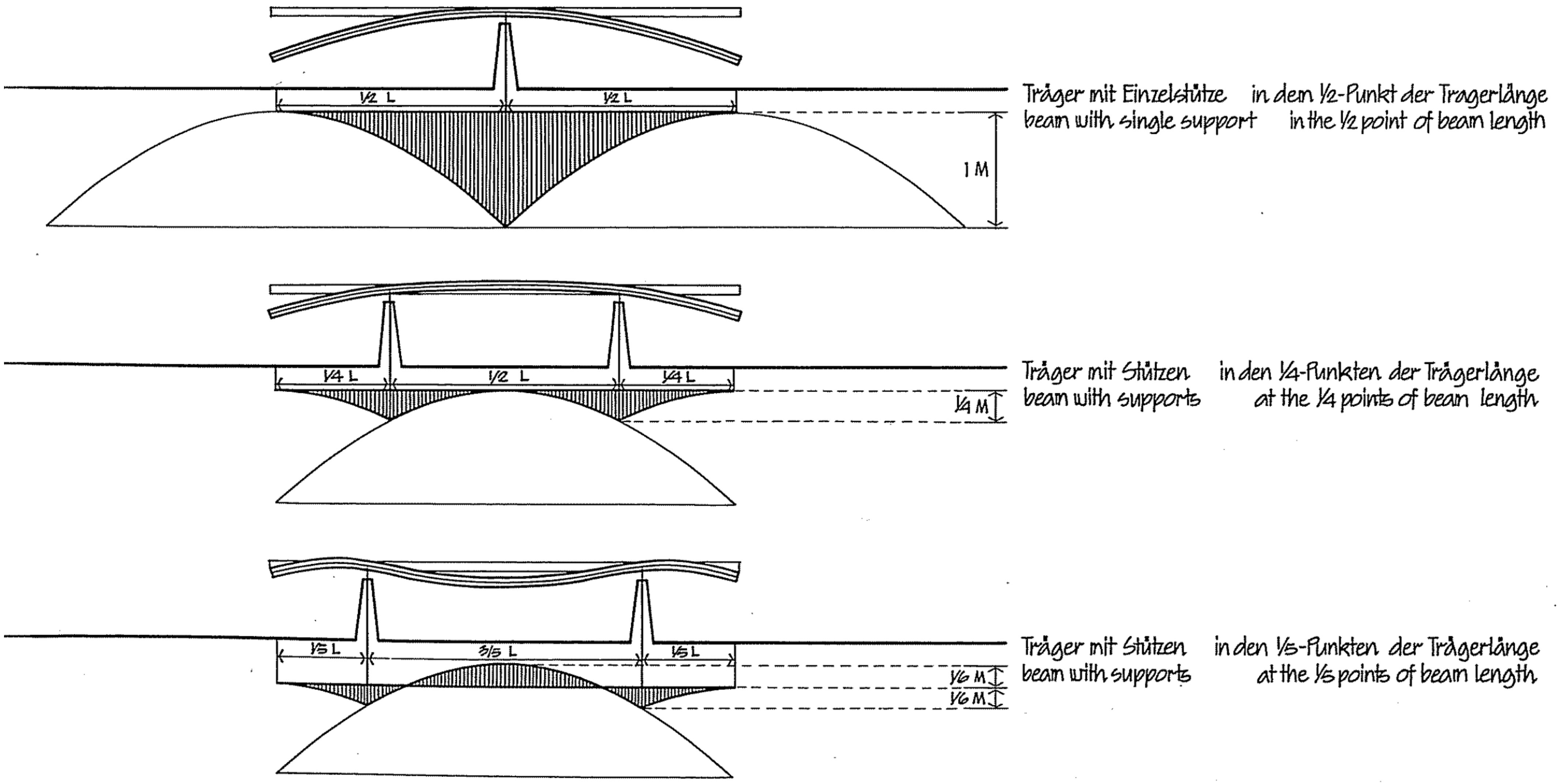
Neben den Standard-Trägerquerschnitten, die durch die Eigenschaften des Baustoffes mitbestimmt werden, führt die Kombination von Baustoffen unter Ausnutzung der konstruktiven Vorzüge des eingesetzten Materials zu neuen, besonders leistungsfähigen Querschnitt-Formen: VERBUNDTRÄGER

In addition to the standard forms of beam sections, largely being determined by the properties of but one structural material, the combination of materials, through the utilization of their respective structural merits, will lead to novel, especially efficient cross sections: COMPOSITE BEAMS

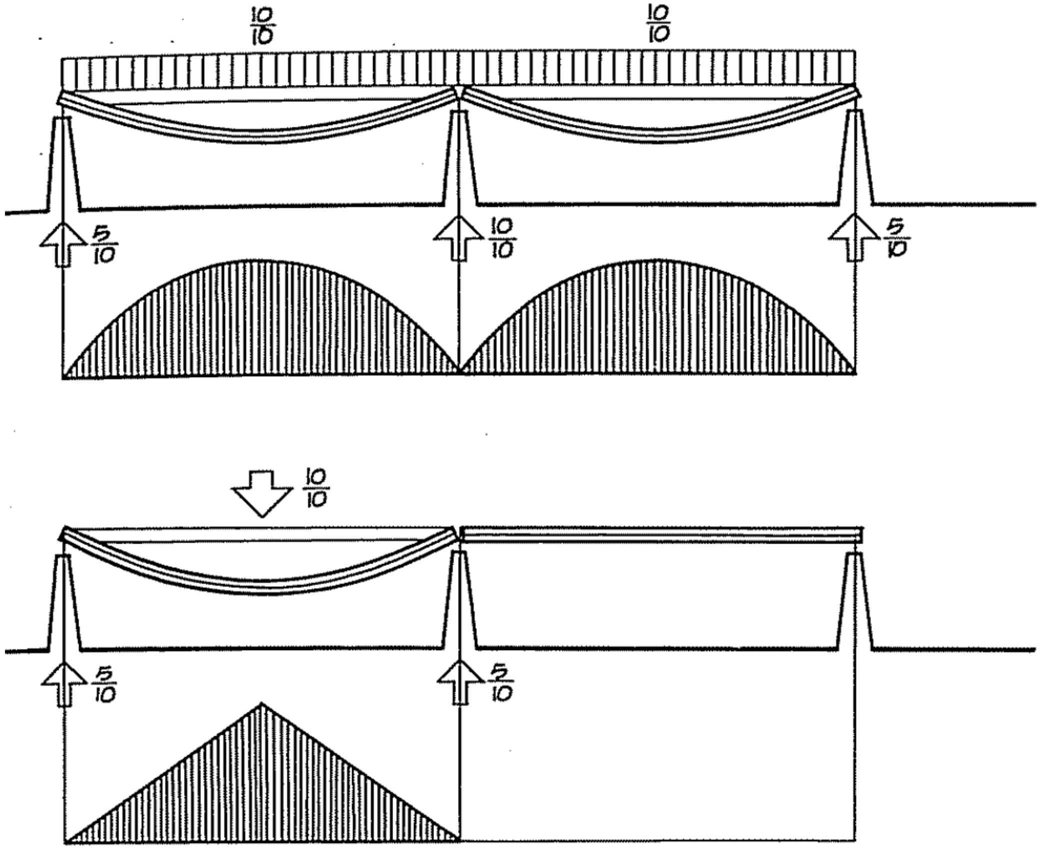
INFLUENCE OF CANTILEVER ACTION ON BEAM EFFICIENCY



INFLUENCE OF SUPPORT CONDITIONS ON BEAM EFFICIENCY

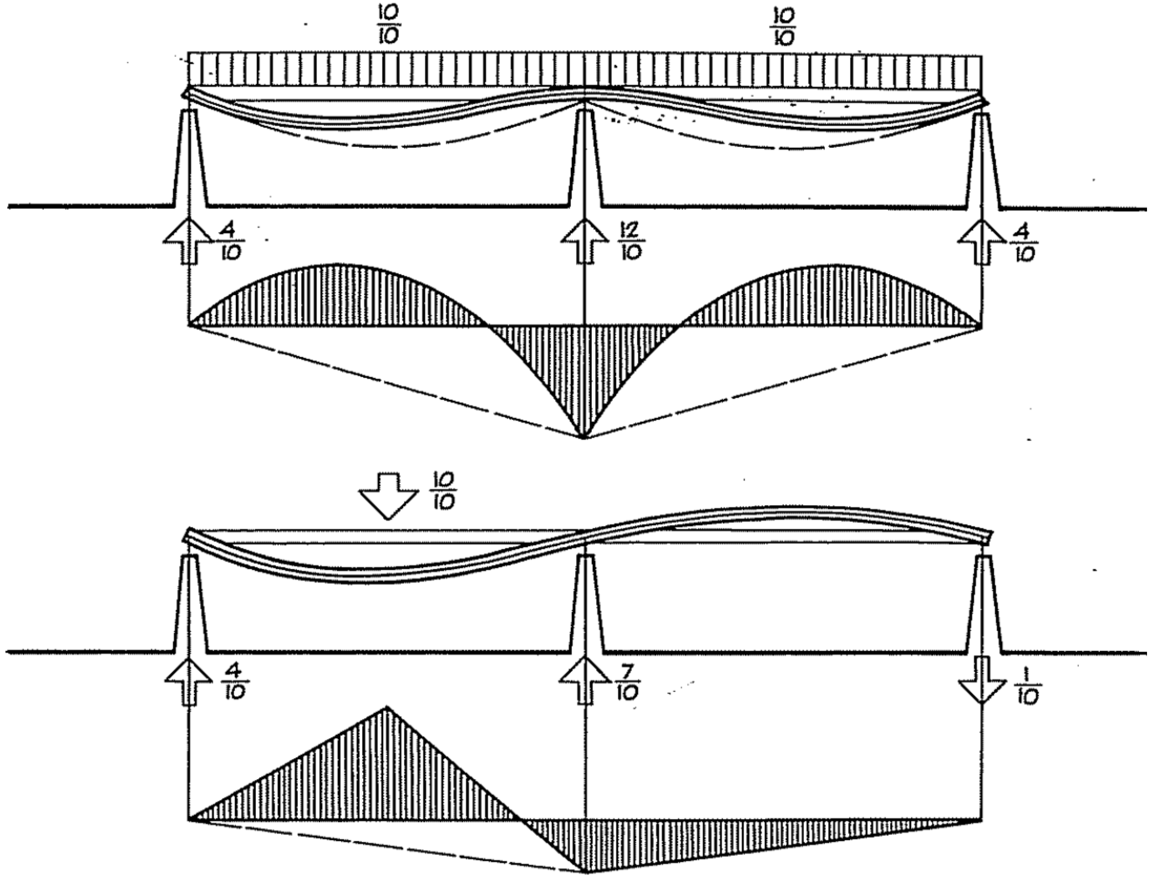


COMPARISON BETWEEN DISCONTINUOUS AND CONTINUOUS BEAMS



Unterbrochener Träger: Durchbiegung in einem Feld wird nicht auf das andere übertragen. Lasten betreffen jedes Feld unabhängig

discontinuous beam: bending deflection in one span will not be carried over to the other. loads will affect each span independantly



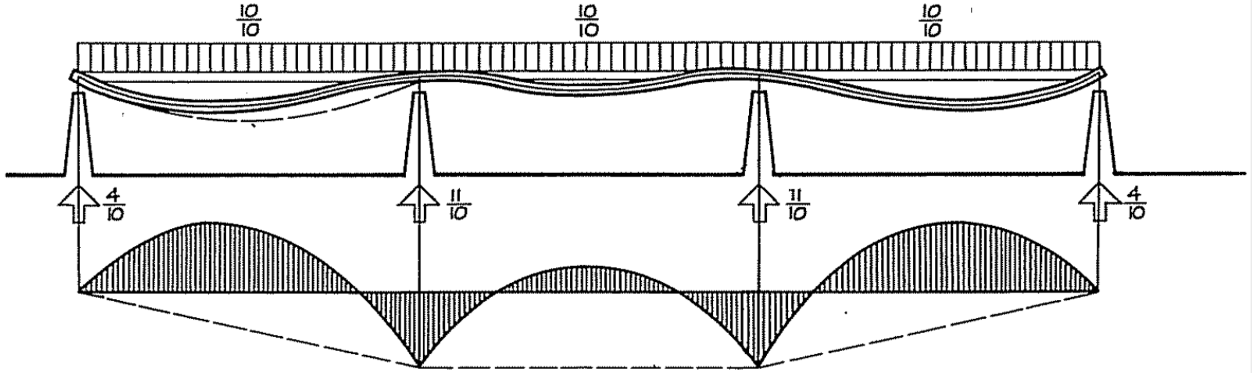
Durchlauf-Träger: Durchbiegung in einem Feld wird auf das andere übertragen. Lasten werden von dem gesanten Träger aufgenommen

continuous beam: bending deflection in one span will be carried over to the other. loads in one span will be resisted by the total length of beam

Streckenlast auf ganze Länge continuous load over entire length

Durch Kontinuierlichkeit ist Drehung des Trägers über den Auflagern behindert. max. Biegung ist in Endfeldern wegen einseitig freier Drehung.

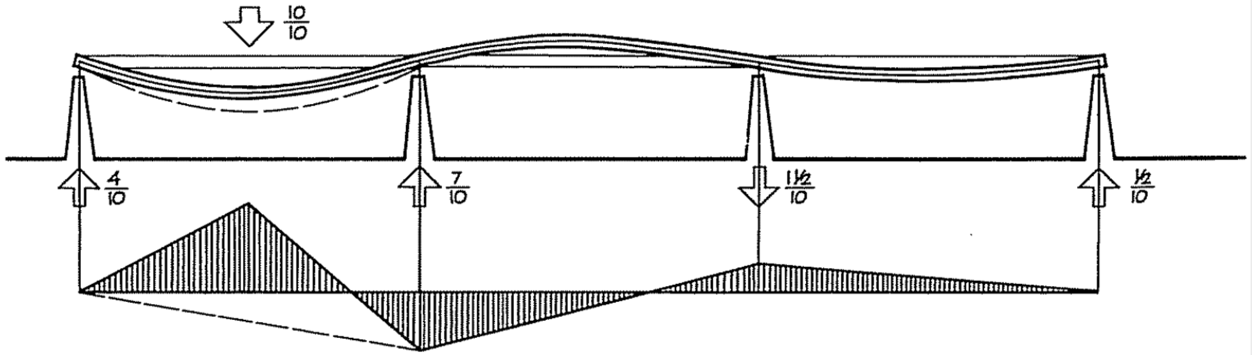
due to continuity, rotation of beam over supports is restrained. max bending occurs in end spans where rotation of one end is not obstructed



Einzellast im Endfeld point load in end span

Durchbiegung im belasteten Feld ist durch einseitige Drehbehinderung vermindert. Auch die unbelasteten Felder nehmen an Lastaufnahme teil.

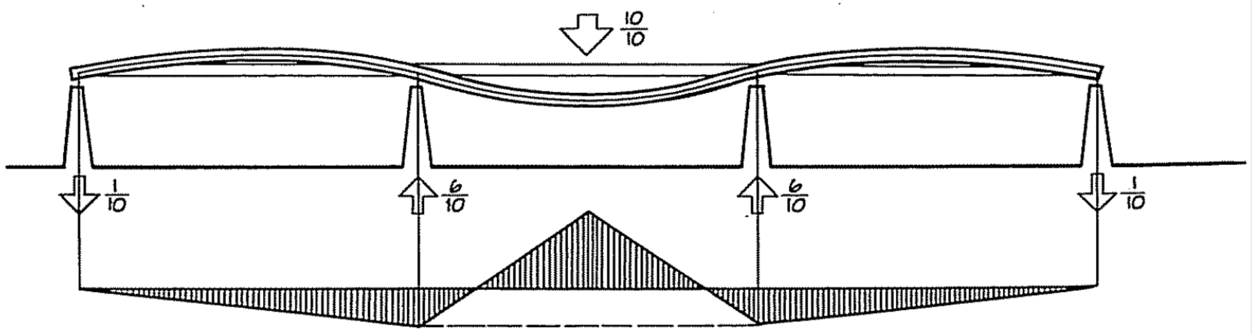
bending deflection in loaded span is restrained by unilateral obstruction of beam rotation. also the unloaded spans participate in resisting load



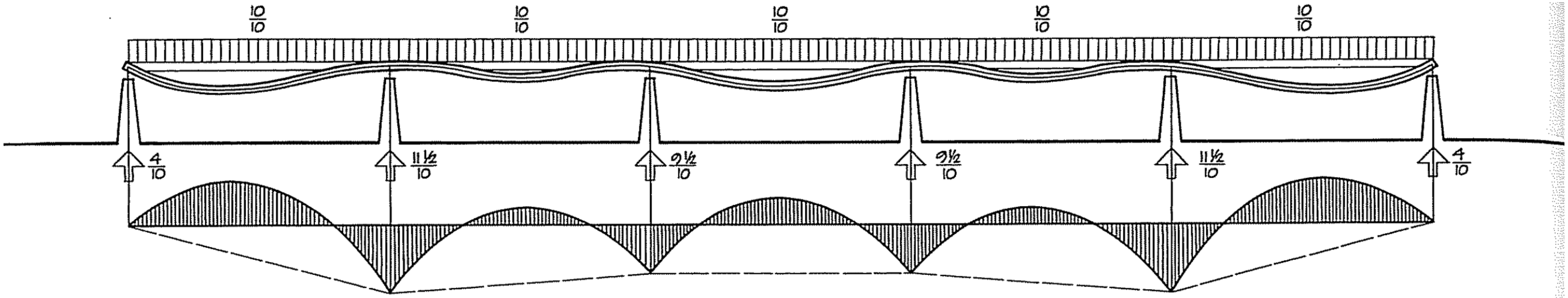
Einzellast im Mittelfeld point load in center span

Durch Kontinuierlichkeit wird Drehung über den Auflagern des belasteten Feldes behindert und der ganze Träger am Tragmechanismus beteiligt

due to continuity, rotation of beam over the supports of loaded span is obstructed. the entire beam is included in the bearing mechanism



BENDING MECHANISM IN CONTINUOUS BEAM OVER 5 SPANS

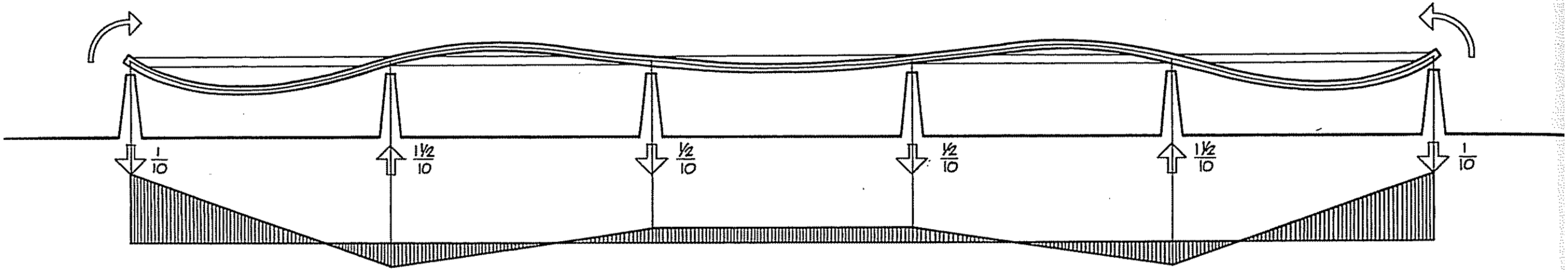


Größe der Biegung unter Gleichstreckenlast

max. Biegung tritt in Endfeldern auf, wo Drehung über Außenstütze nicht behindert wird. min. Biegung ist in Feldern neben Endfeldern

magnitude of bending under continuous load

max bending occurs in end span where rotation over exterior support is not restrained. min bending occurs in spans next to end spans



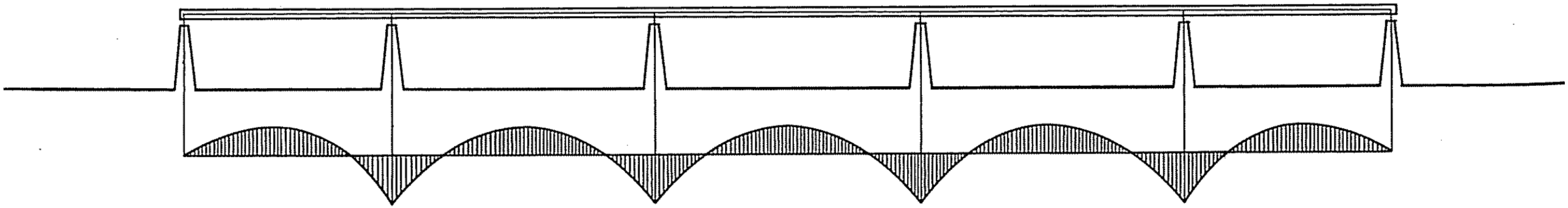
Einfluß des größeren Endfeld-Momentes

Mangel an Drehbehinderung über den Endstützen beeinflußt die Biegung der anderen Felder in gleicher Weise wie ein zusätzliches Drehmoment

influence of major moment in end span

lack of restraining moment over end supports influences the deflections of the other spans in the same way as does an additional rotation moment

POSSIBILITY OF EQUAL DISTRIBUTION OF BENDING IN CONTINUOUS BEAM

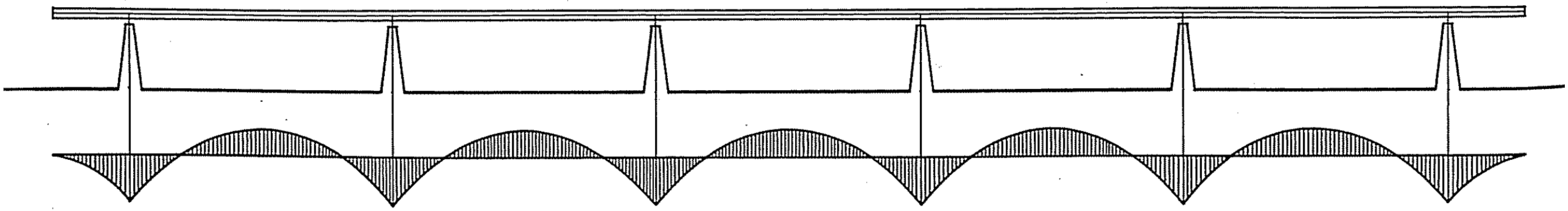


Verkleinerung der Endfelder

Durch Verkürzung der Biegelänge kann die Durchbiegung im Endfeld auf das Maß der Durchbiegung in den anderen Feldern gebracht werden

reduction of end span

through shortening the beam length in the end span, bending in this span can be brought down to that of the other spans



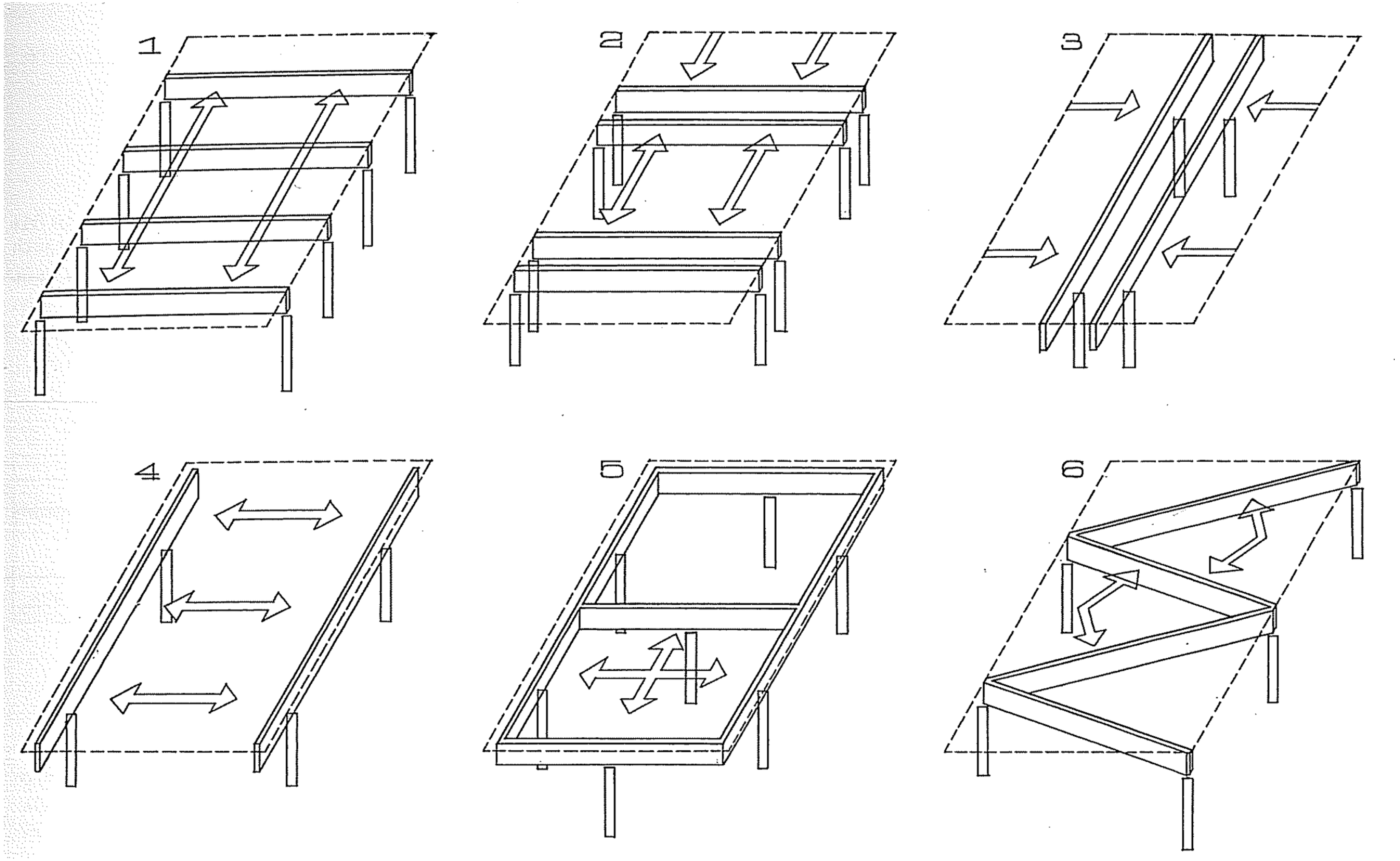
Auskragung über die Endstützen

Durch die Gegendrehung der Auskragung wird die Durchbiegung im Endfeld auf das Maß der Durchbiegung in den anderen Feldern gebracht

cantilevers at the ends

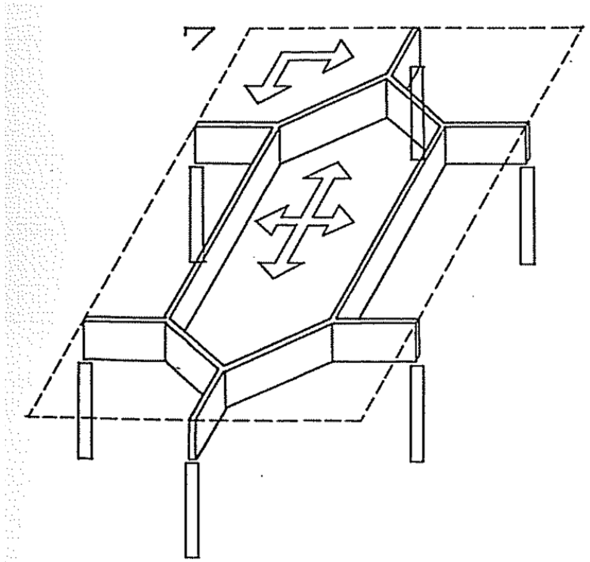
due to the reverse rotation of the cantilevers, bending in the end span can be brought down to that of the other spans

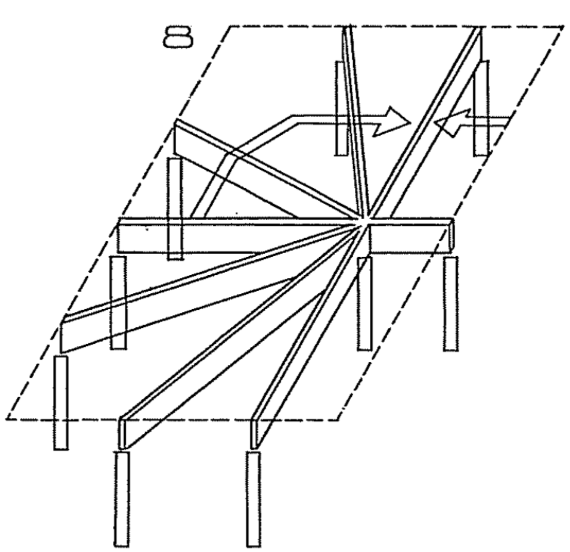
BEAM LAYOUTS FOR LOAD TRANSMISSION (1/2)

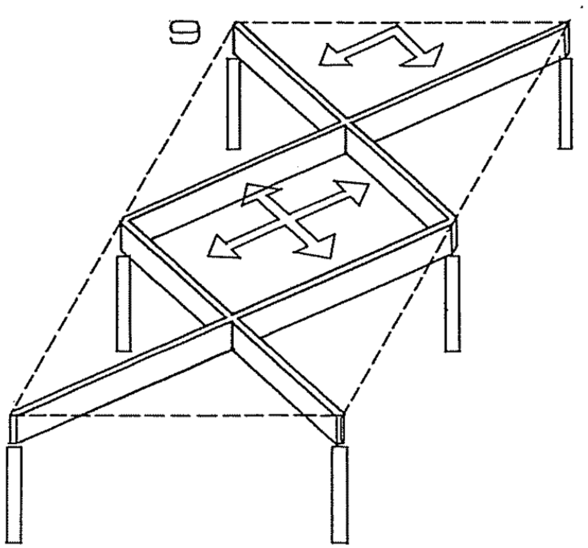


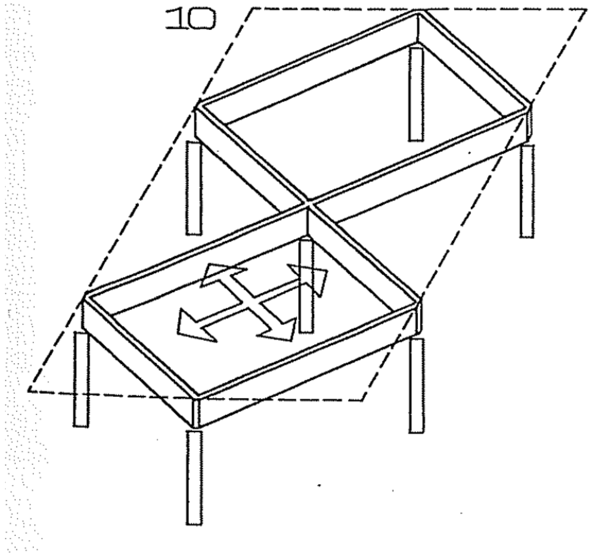
1 Transversal alignment
2 Transversal coupling
3 Longitudinal coupling
4 Longitudinal edge position
5 Square grid
6 Zigzag skew pattern

BEAM LAYOUTS FOR LOAD TRANSMISSION (2/2)









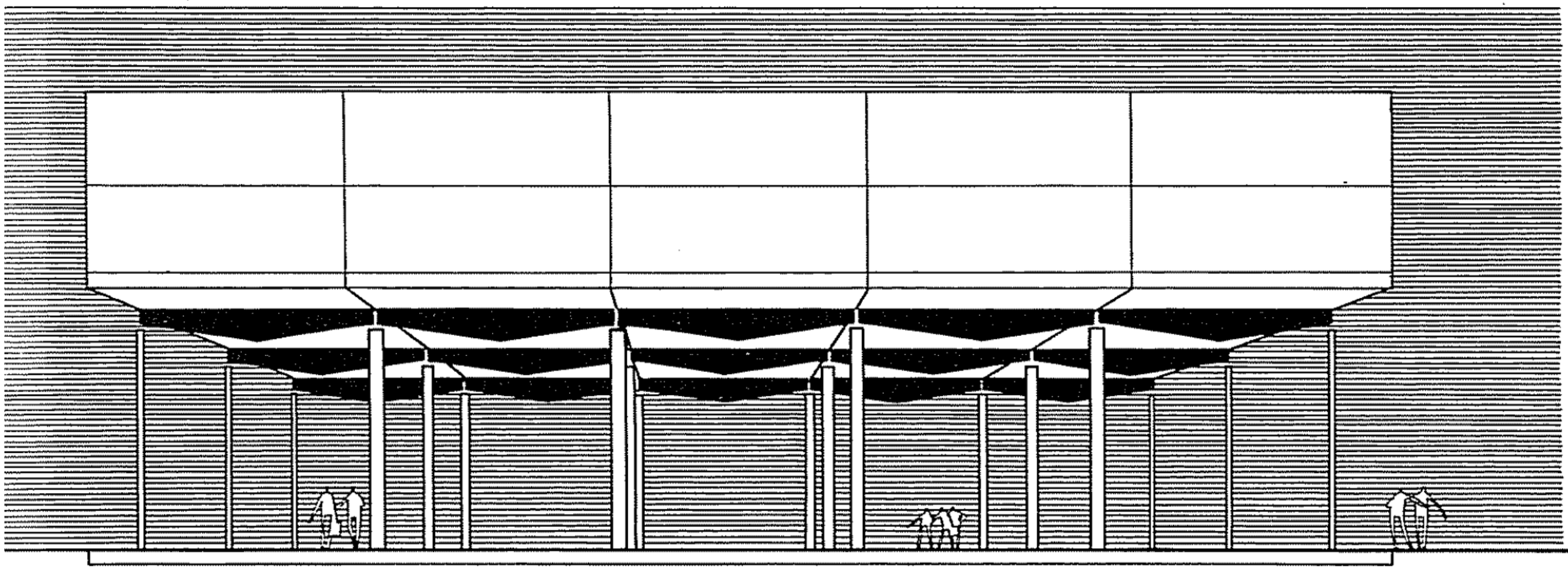
Balkenanordnungen für Lastabtragung · Beam layouts for load transmission

1	Querreihung	1	Transversal alignment
2	Querbündelung	2	Transversal coupling
3	Längsbündelung	3	Longitudinal coupling
4	Längsrandlage	4	Longitudinal edge position
5	Quadratraster	5	Square grid
6	Zickzack-Schrägführung	6	Zigzag skew pattern
7	Verzweigung	7	Ramification
8	Radialmuster	8	Radial pattern
9	Diagonalkreuzung	9	Diagonal crossing
10	Diagonalraster	10	Diagonal grid

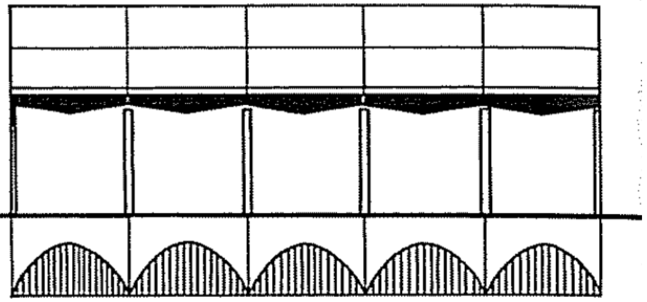
STRUCTURE SYSTEMS AND DESIGN POSSIBILITIES FOR BEAM OVER FIVE SPANS (1/5)

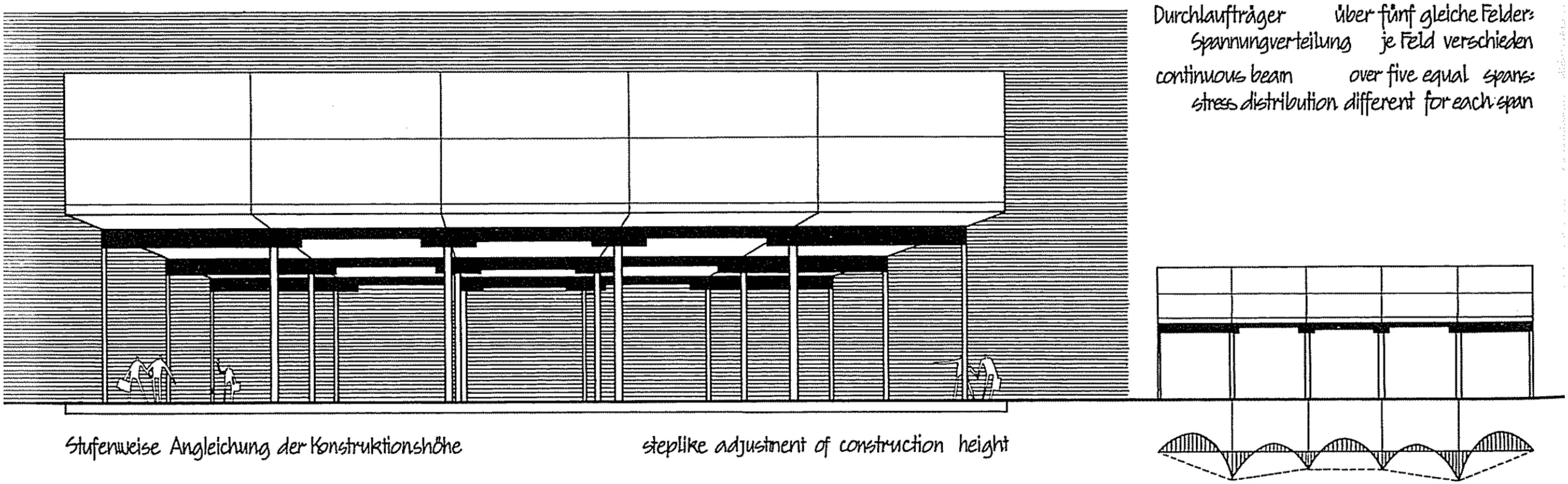
Einzelträger (unterbrochener Tr.) für jedes Feld:
Spannungsverteilung für jedes Feld gleich

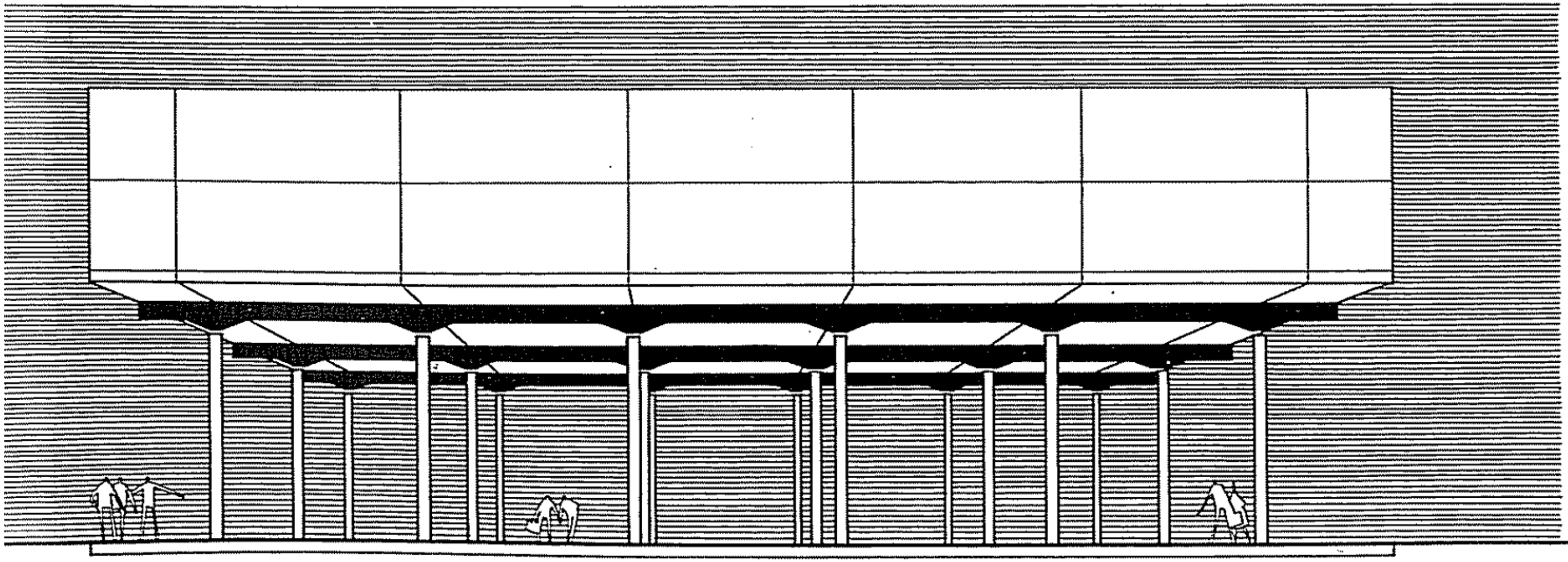
discontinuous beam one for each span:
stress distribution equal for each span



Gradlinige Vergrößerung der Konstruktionshöhe zur Feldmitte linear increase of construction height toward midspan

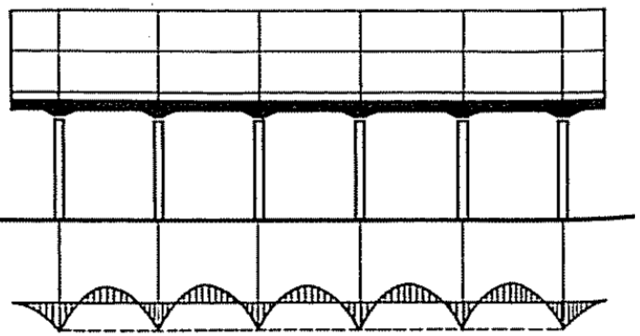



Durchlaufträger über fünf gleiche Felder:
Spannungverteilung je Feld verschieden
continuous beam over five equal spans:
stress distribution different for each span
Stufenweise Angleichung der Konstruktionshöhe
steplike adjustment of construction height

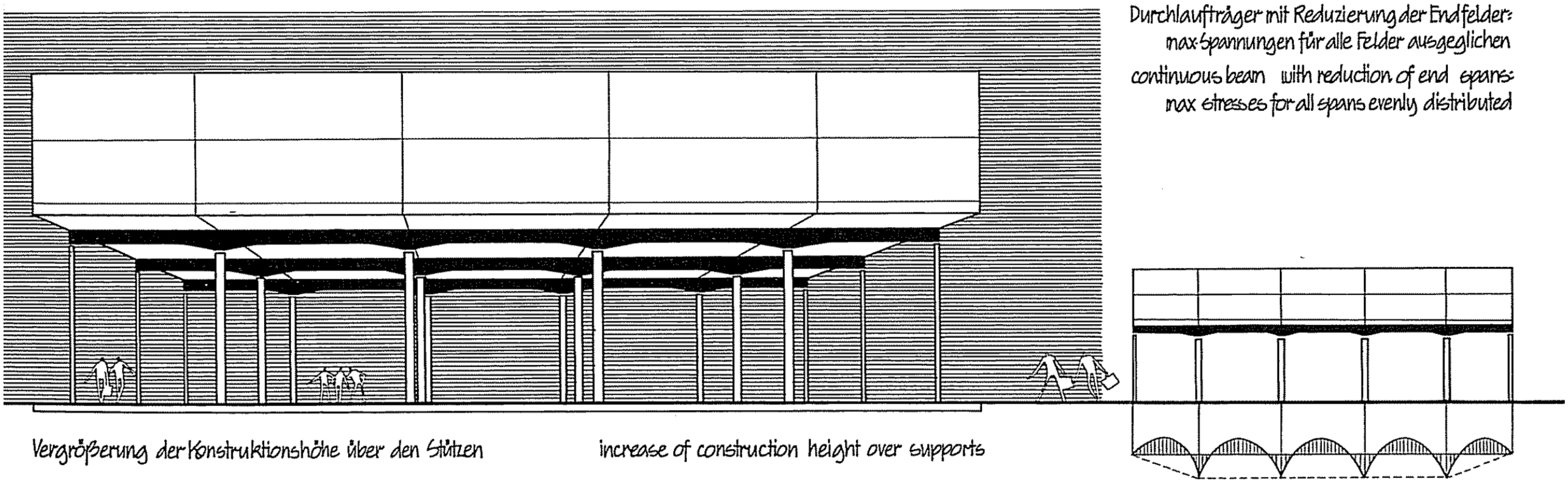


Durchlaufträger mit Kragarmen an den Enden:
Spannungsverteilung für jedes Feld gleich

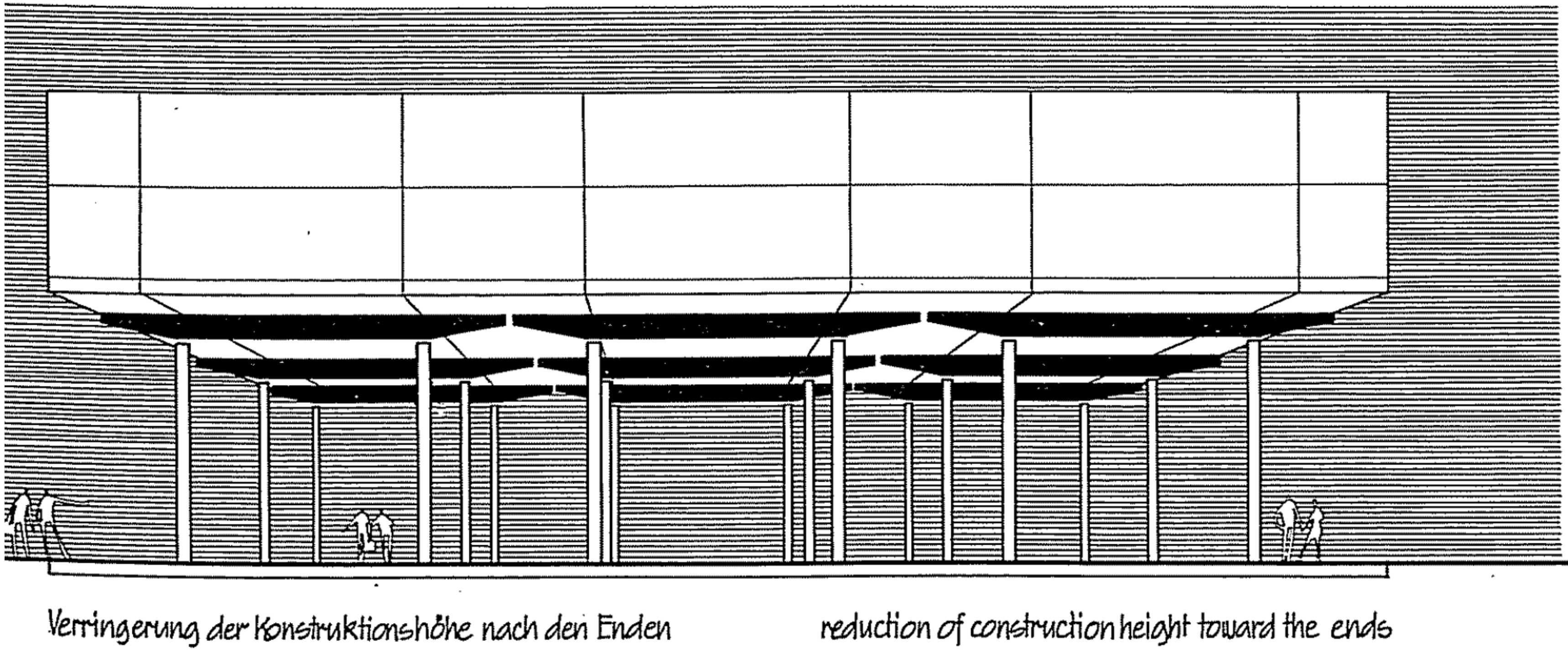
continuous beam with cantilevered ends:
stress distribution equal for each span



STRUCTURE SYSTEMS AND DESIGN POSSIBILITIES FOR BEAM OVER FIVE SPANS (4/5)

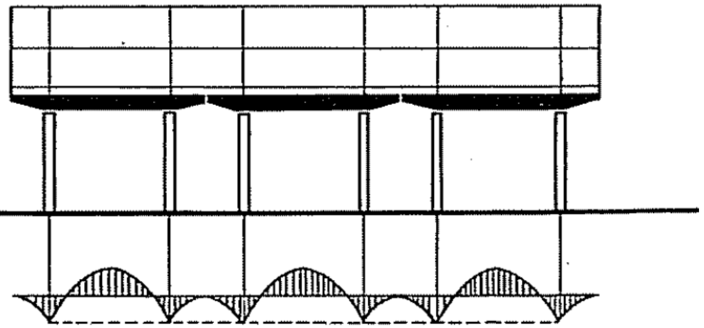


STRUCTURE SYSTEMS AND DESIGN POSSIBILITIES FOR BEAM OVER FIVE SPANS (5/5)

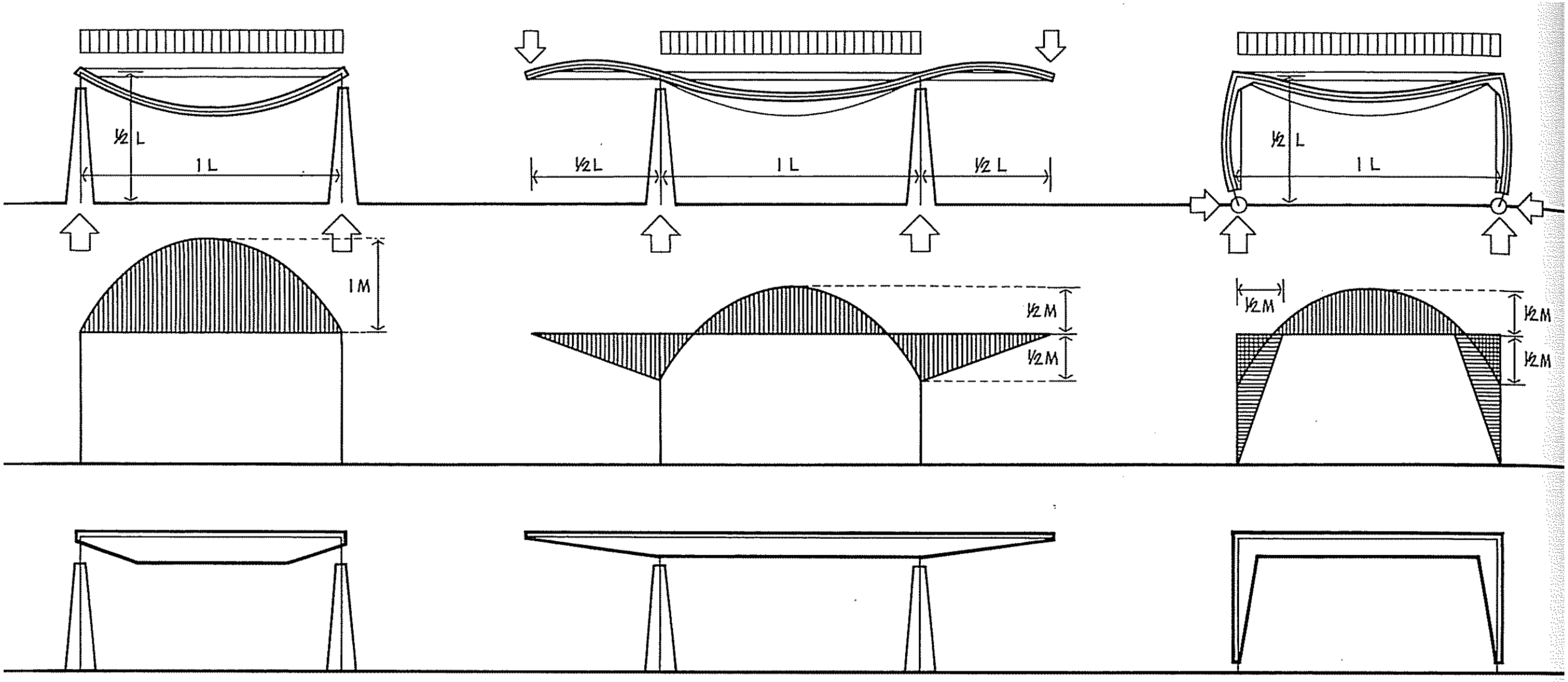


Drei Einzelträger mit Kragarmen an den Enden: Spannungsverteilung für jeden Träger gleich

three discontinuous beams with cantilevered ends: stress distribution equal for each span



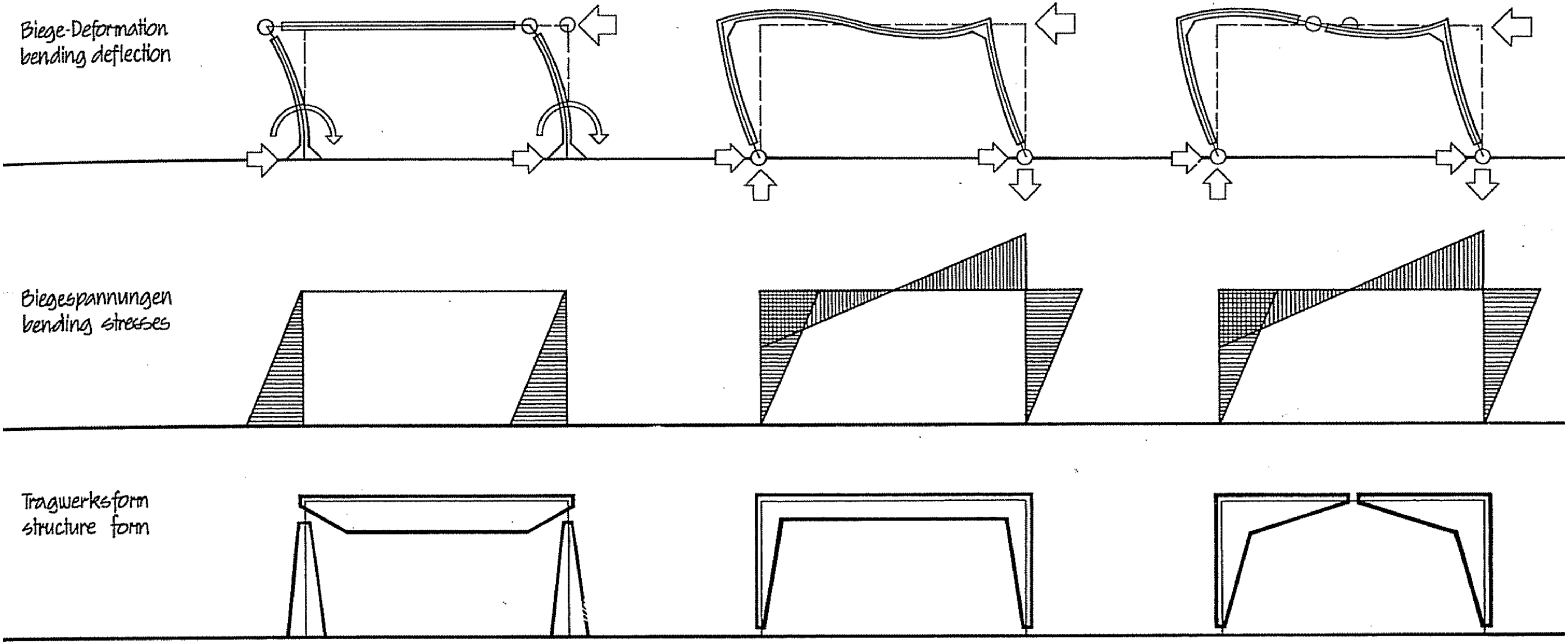
MECHANISM OF FRAME AND ITS RELATIONSHIP TO THE BEAM WITH CANTILEVERS



Die Horizontalkräfte an den Fußpunkten des Rahmens schränken Drehung der Rahmenecke ein und verringern Durchbiegung des Riegels in gleicher Weise wie die Einzellasten an den Enden eines Trägers mit Kragarmen

the horizontal reactions at the bases of the frame obstruct rotation of the frame corners and reduce deflection of the frame beam in the same way as do the point loads at the ends of a beam with cantilevers

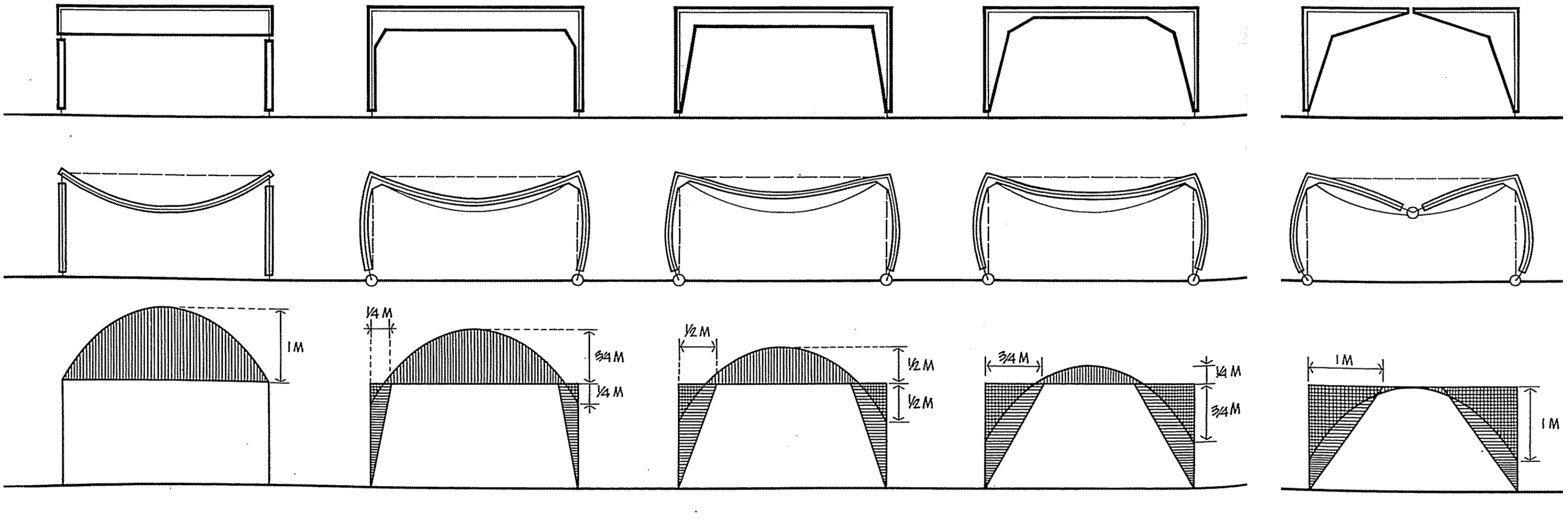
MECHANISM OF RESISTING LATERAL FORCES



Im Gegensatz zum einfachen Träger, der zusätzliche Aussteifung der Stützen benötigt, um das Drehmoment aufzunehmen, werden im Gelenkrahmen durch die Verformung selbst senkrechte Auflagerkräfte aktiviert, die eine gegenläufige Drehung auslösen

contrary to the simple beam that needs additional stiffening of supports for receiving the rotation moment, in the rigid frame by its own deflection vertical reactions are generated that produce a reverse rotation

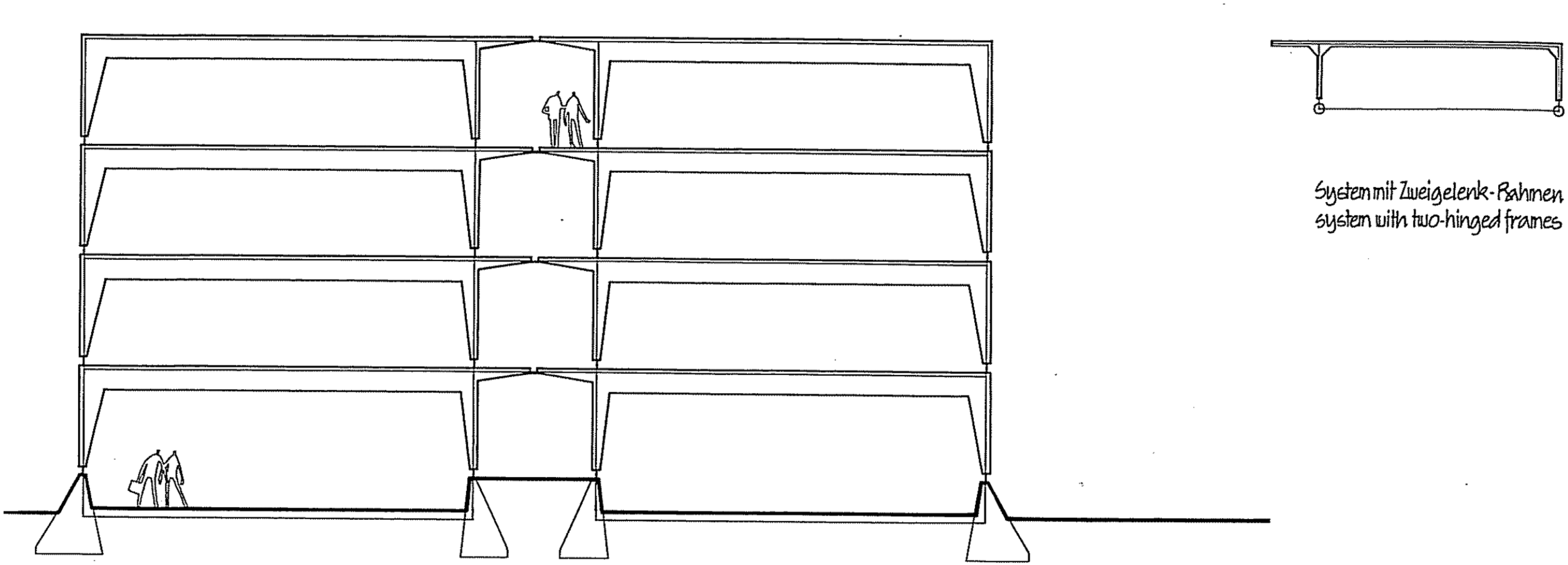
INFLUENCE OF FRAME STIFFNESS ON STRESS DISTRIBUTION AND STRUCTURE FORM



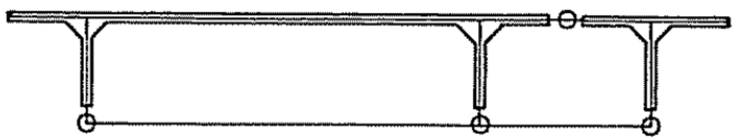
Beam | Two-hinge frame | Three-hinge frame

due to continuity over the frame corners, deflection of the beam can be reduced differently according to the degree of column stiffness. this results in control over degree of deflection and hence over structure form

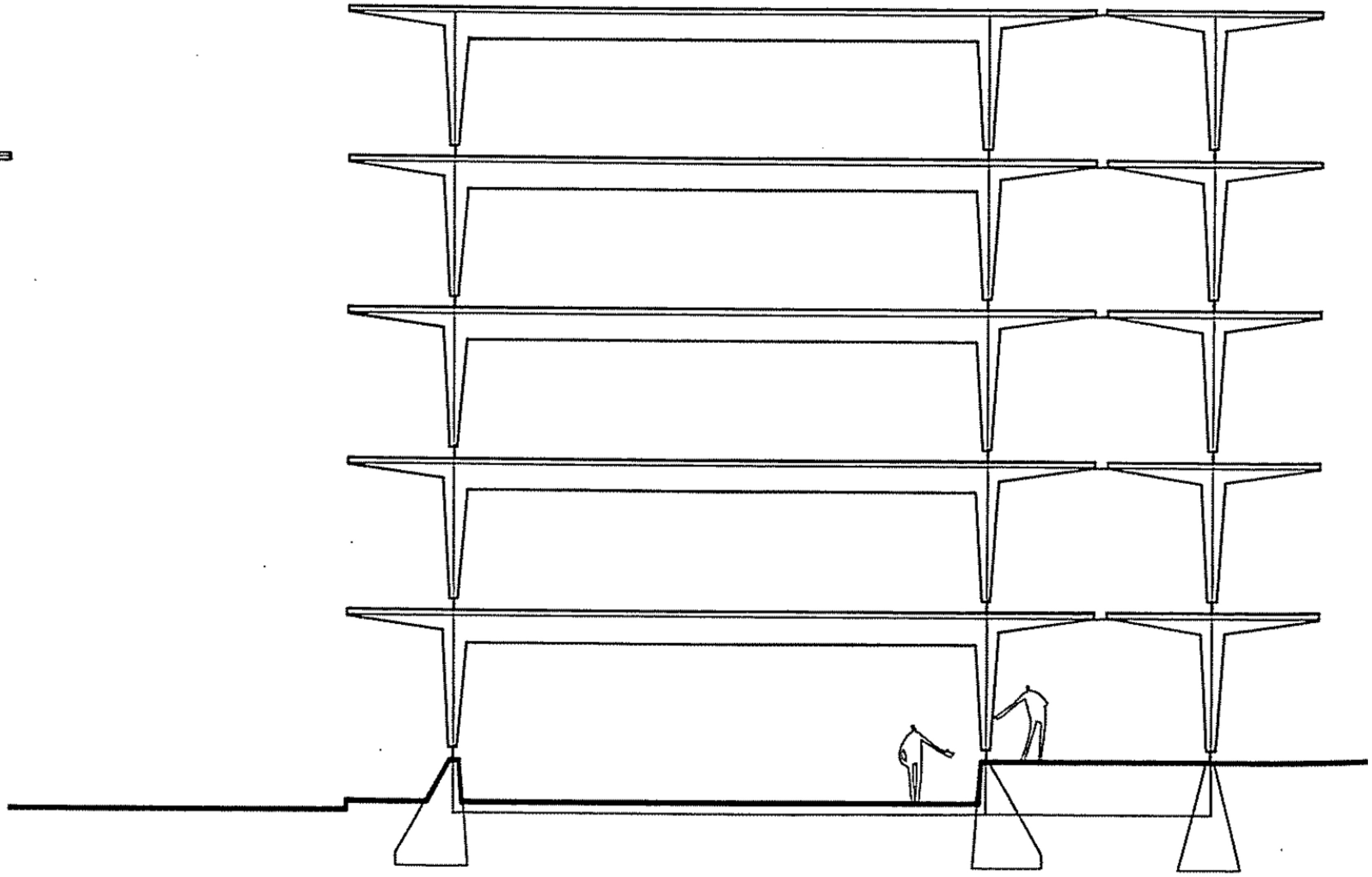
HORIZONTAL AND VERTICAL STRUCTURE SYSTEMS COMPOSED OF HINGED FRAMES (1/3)



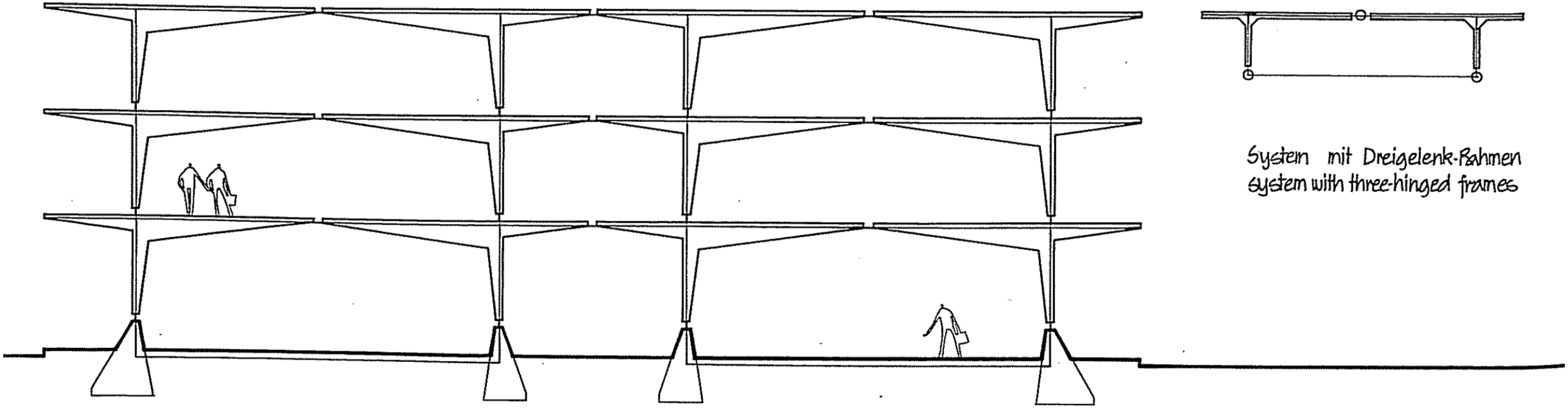
HORIZONTAL AND VERTICAL STRUCTURE SYSTEMS COMPOSED OF HINGED FRAMES (2/3)



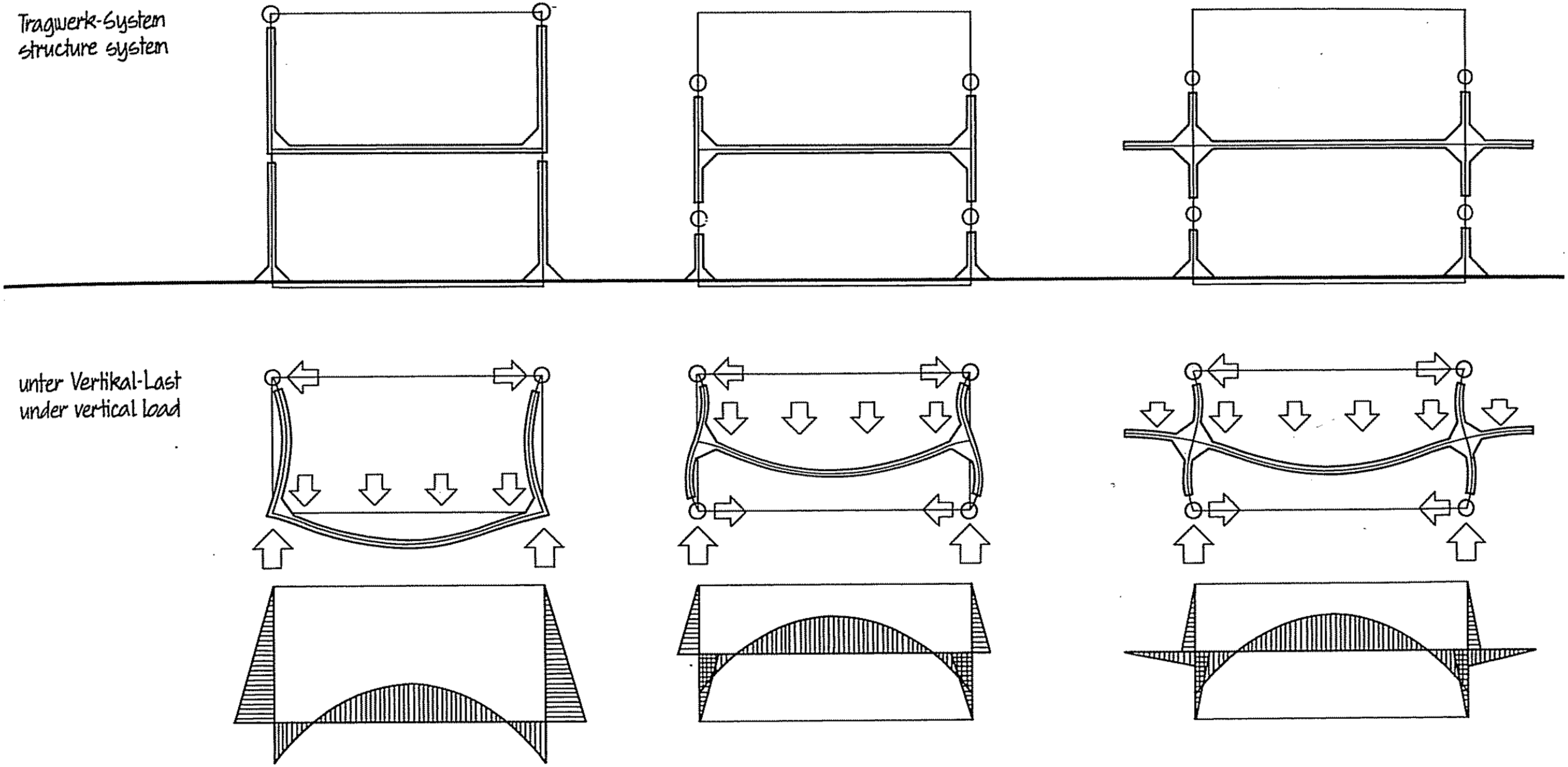
System mit Zweigelenk-Rahmen und T-Rahmen
system with two-hinged frames and T-frames



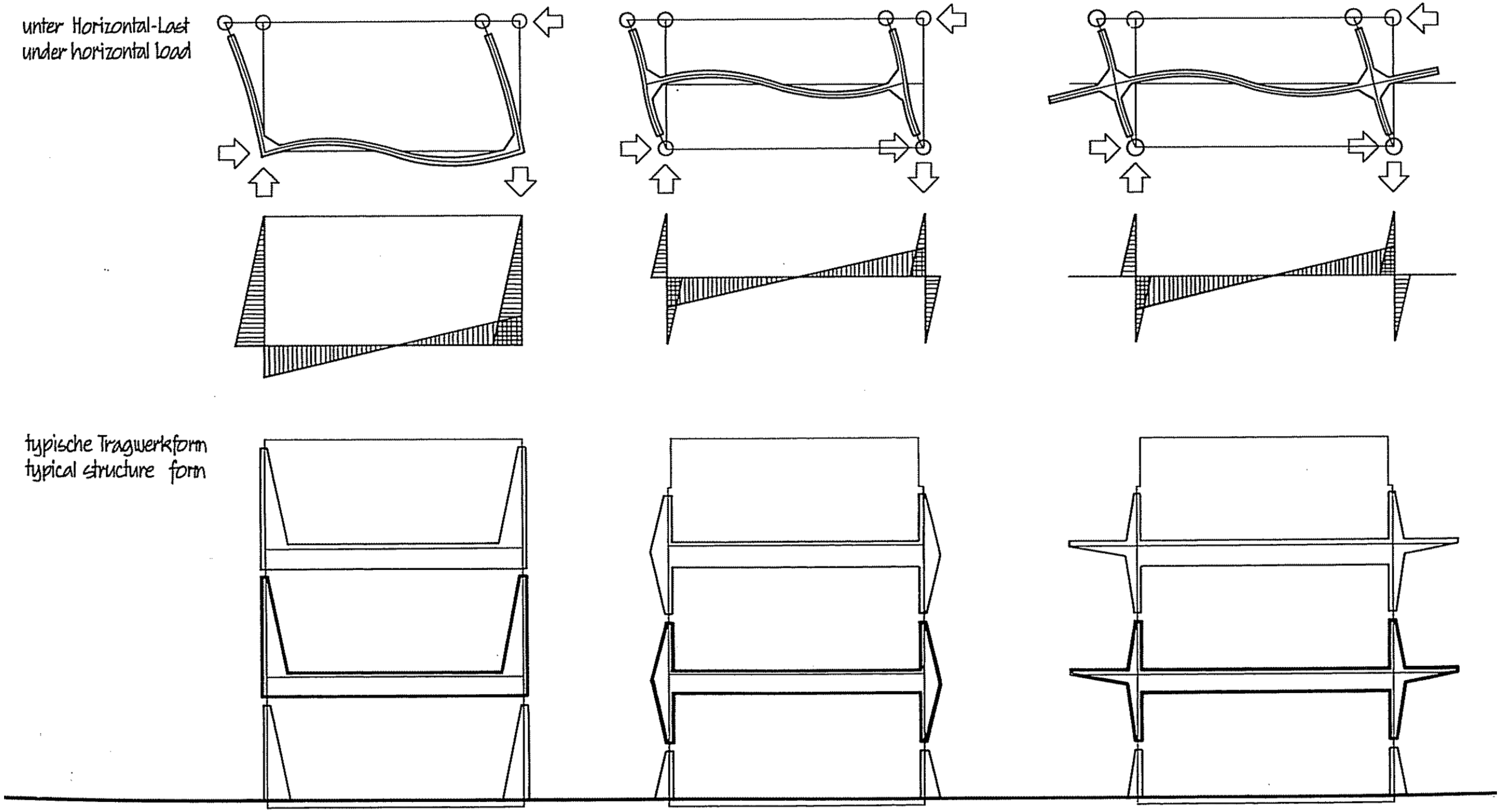
HORIZONTAL AND VERTICAL STRUCTURE SYSTEMS COMPOSED OF HINGED FRAMES (3/3)



MECHANISM OF THE REVERSE AND DOUBLED FORM OF TWO-HINGED FRAME (1/2)



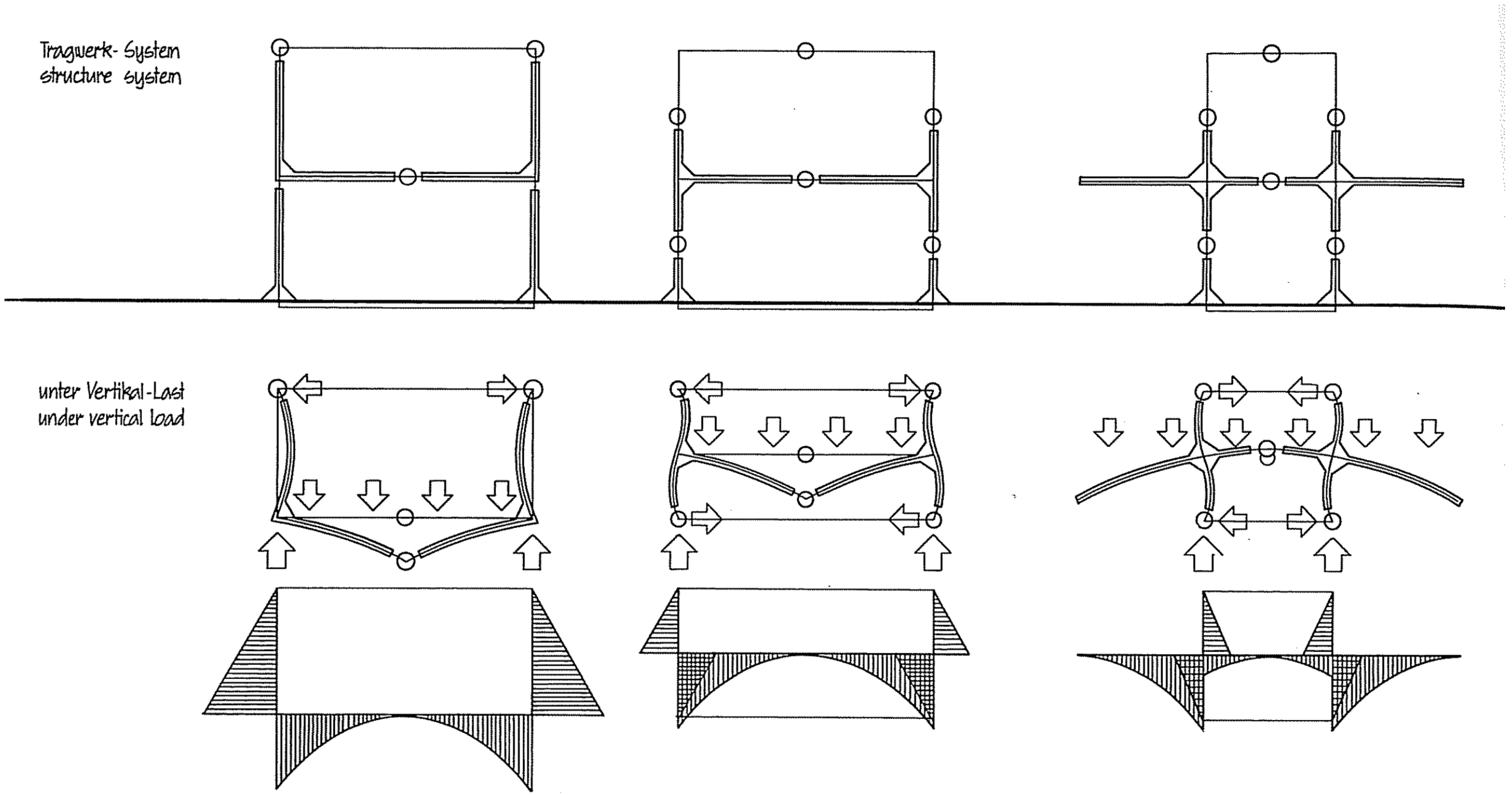
MECHANISM OF THE REVERSE AND DOUBLED FORM OF TWO-HINGED FRAME (2/2)



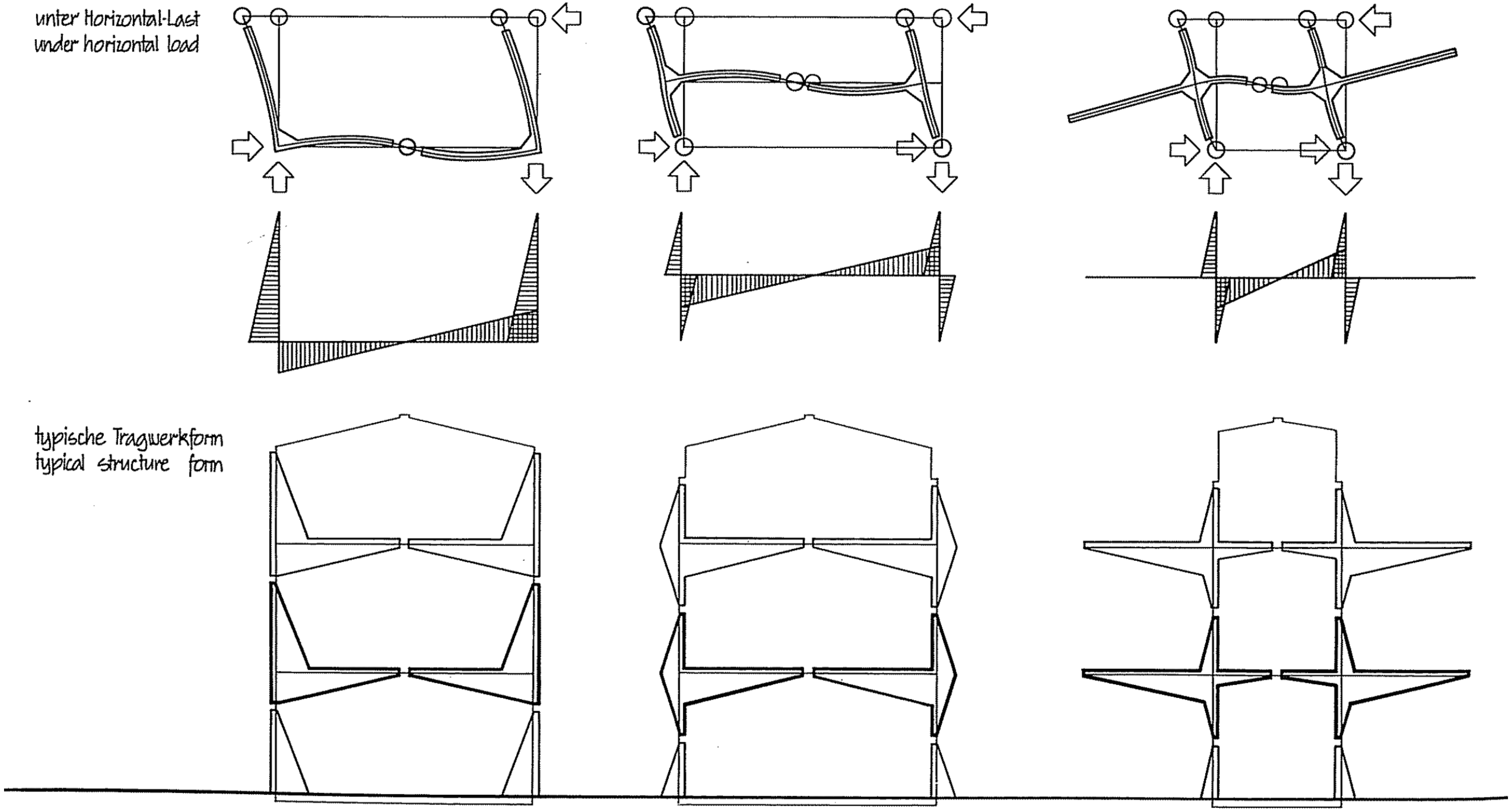
Der typische Tragmechanismus des Zweigelenk-Rahmens bleibt auch nach Umkehrung des Rahmens oder Aufdoppelung von zusätzlichen Stielen unvermindert wirksam

the typical bearing mechanism of the two-hinged frame will function with undiminished efficiency also after reversal of the frame or after doubling up additional columns

MECHANISM OF THE REVERSE AND DOUBLED FORM OF THREE-HINGED FRAME (1/2)

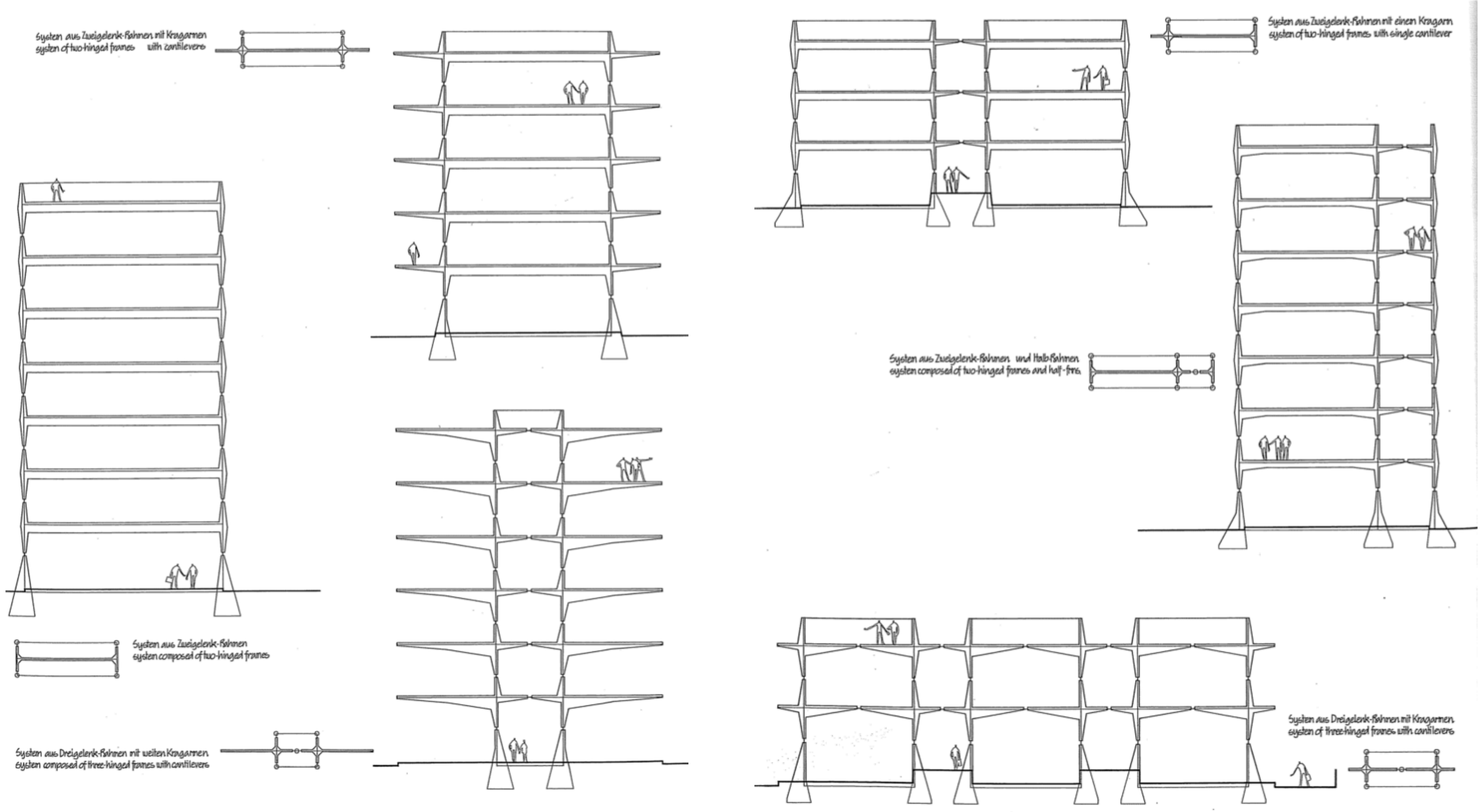


MECHANISM OF THE REVERSE AND DOUBLED FORM OF THREE-HINGED FRAME (2/2)

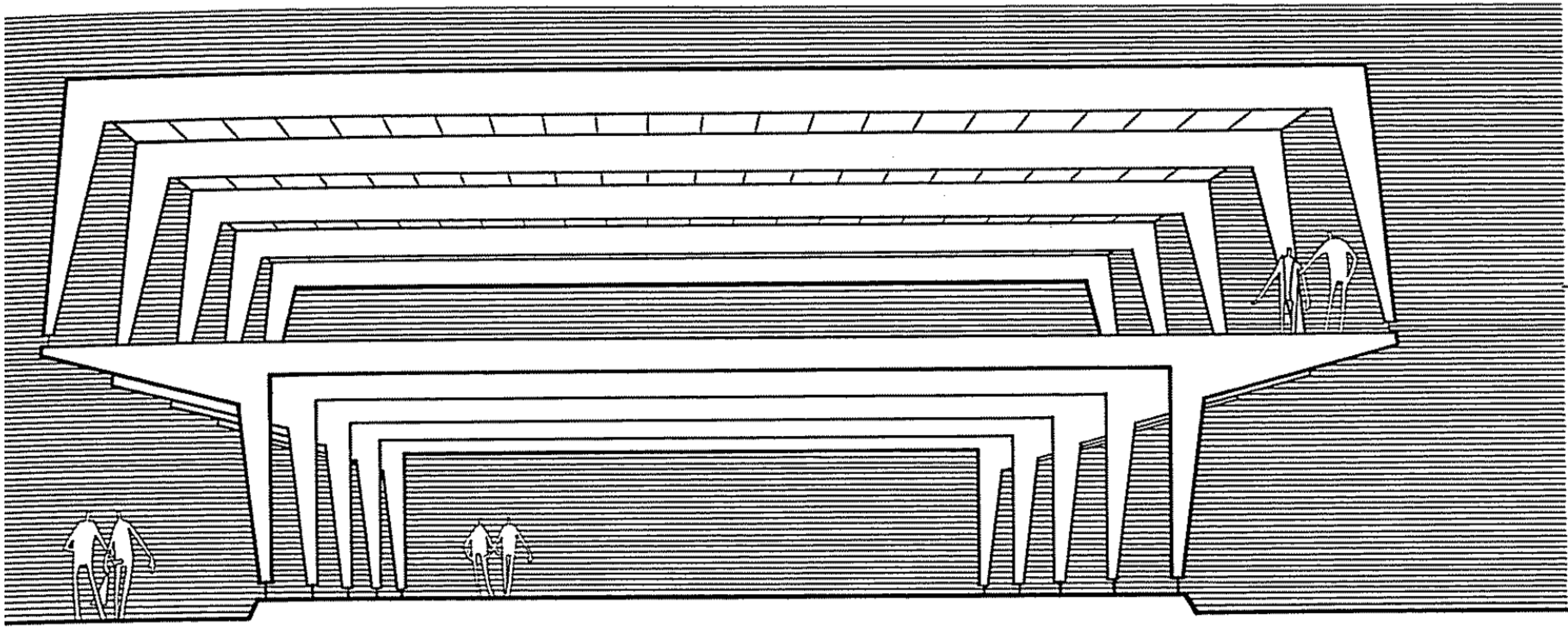


Der typische Tragmechanismus des Dreigelenk-Rahmens bleibt auch nach Umkehrung des Rahmens oder Aufdoppelung von zusätzlichen Stielen unvermindert wirksam

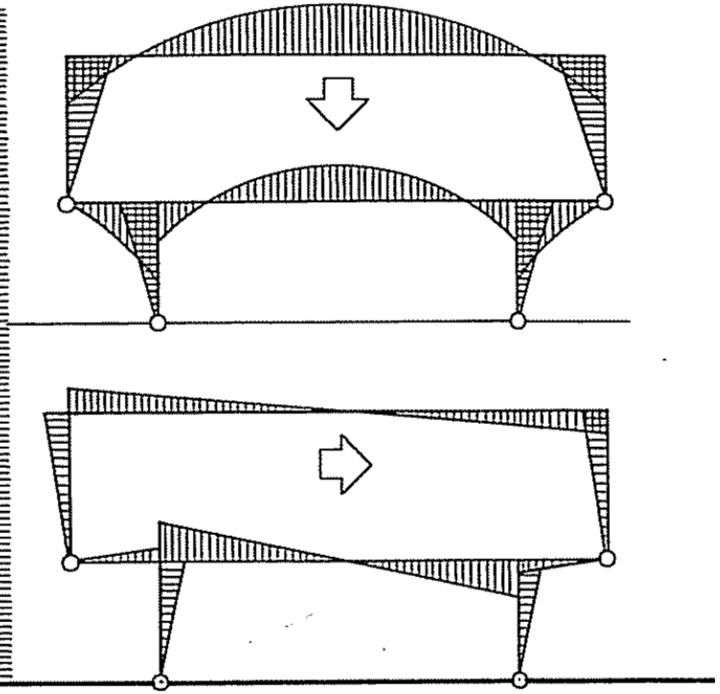
the typical bearing mechanism of the three-hinged frame will function with undiminished efficiency also after reversal of frame or doubling up additional columns


System aus Zweigelenk-Rahmen mit Kragarmen
system of two-hinged frames with cantilevers
System aus Zweigelenk-Rahmen
system composed of two-hinged frames
System aus Dreigelenk-Rahmen mit weiten Kragarmen
system composed of three-hinged frames with cantilevers
System aus Zweigelenk-Rahmen mit einem Kragarm
system of two-hinged frames with single cantilever
System aus Zweigelenk-Rahmen und Halb-Rahmen
system composed of two-hinged frames and half-frms
System aus Dreigelenk-Rahmen mit Kragarmen
system of three-hinged frames with cantilevers

DESIGN POSSIBILITIES WITH HINGED FRAME SYSTEMS (1/3)

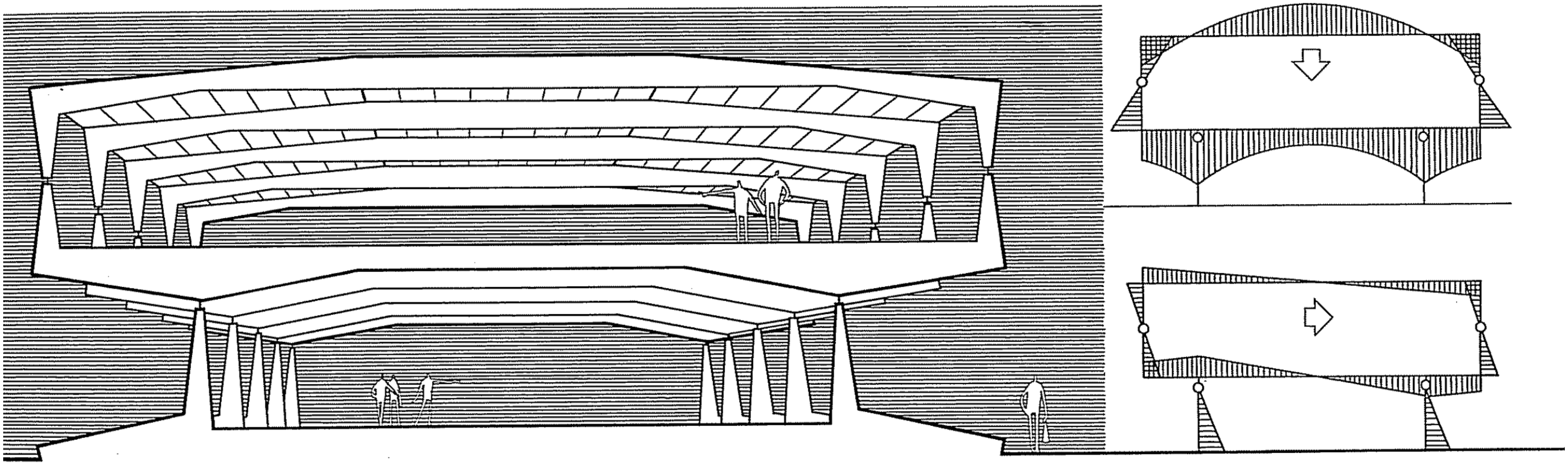


Zweigelenk-Rahmen aufgesetzt auf Kragarme eines Zweigelenk-Rahmens



two-hinged frame set upon cantilevers of two-hinged frame

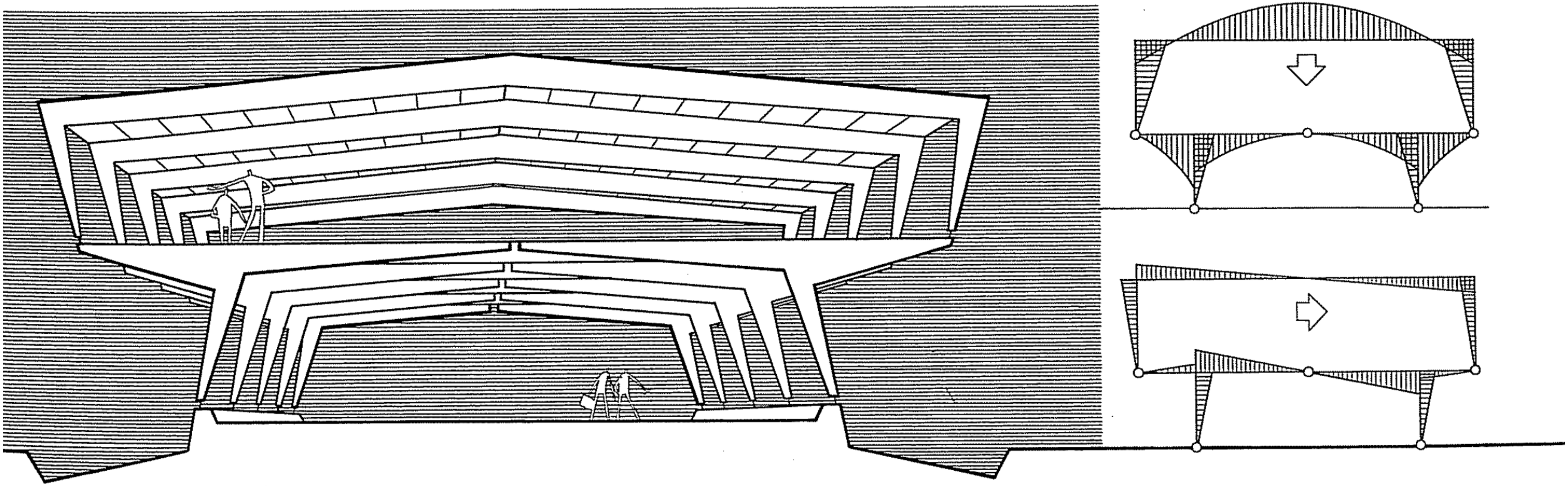
DESIGN POSSIBILITIES WITH HINGED FRAME SYSTEMS (2/3)



Zweigelenk-Rahmen aufgesetzt auf umgekehrten Zweigelenk-Rahmen über Stützen

two-hinged frame set upon reverse two-hinged frame upon supports

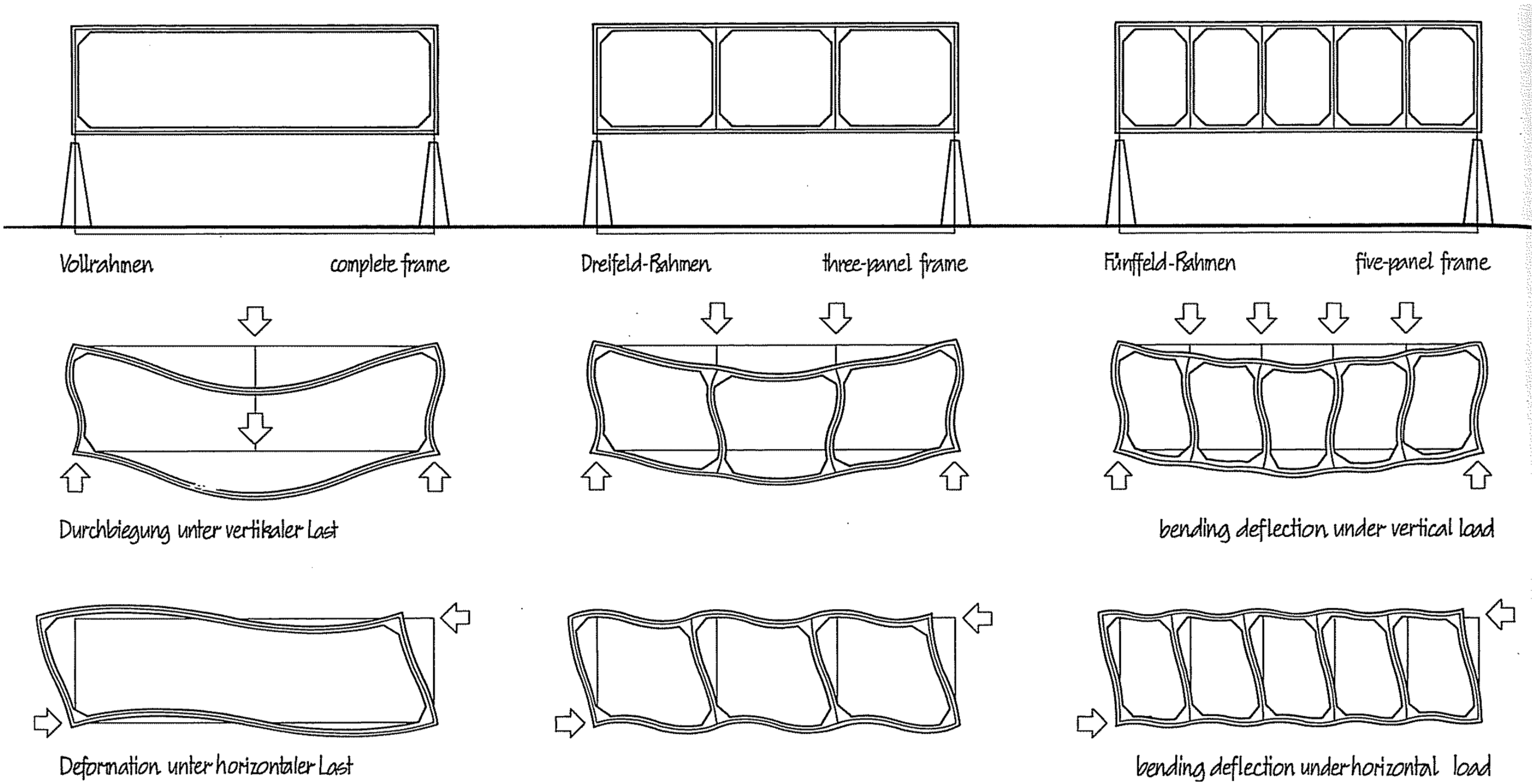
DESIGN POSSIBILITIES WITH HINGED FRAME SYSTEMS (3/3)

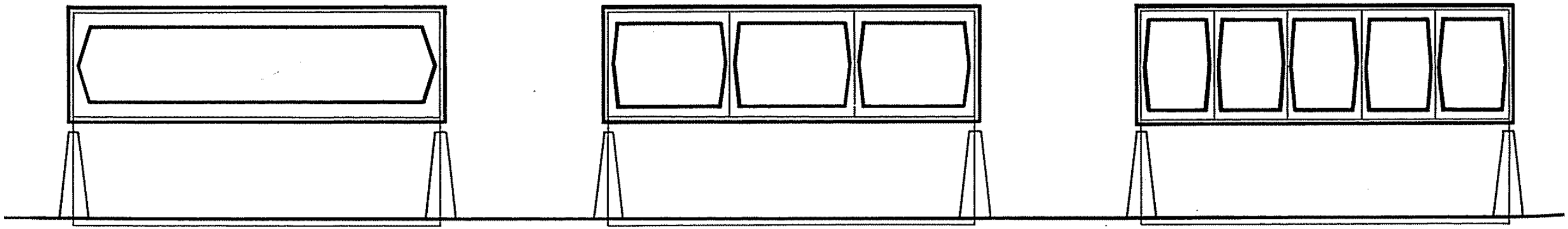


Zweigelenk-Rahmen aufgesetzt auf Kragarme eines Dreigelenk-Rahmens

two-hinged frame set upon cantilevers of three-hinged frame.

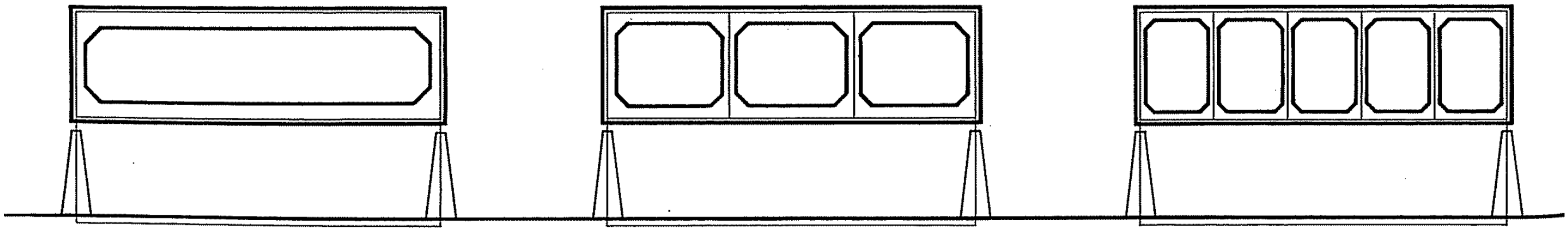
MECHANISM OF COMPLETE FRAME AND MULTI-PANEL FRAME (1/2)





Tragwerkform mit Betonung der Stelle geringster Biegebelastung

structure form with emphasis on location of min bending stresses



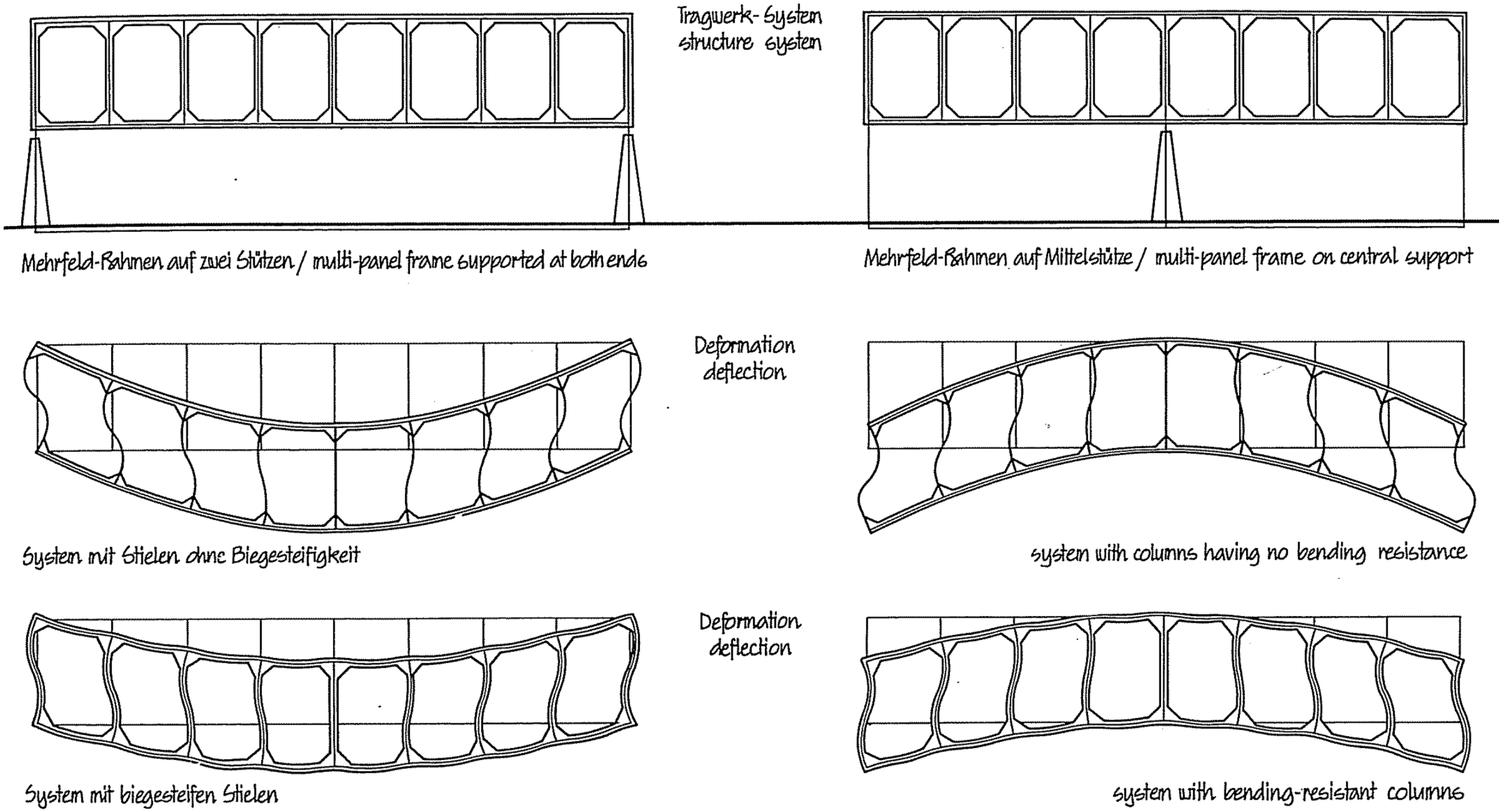
Tragwerkform mit Betonung der Eckversteifung

structure form with emphasis on stiffening of corners

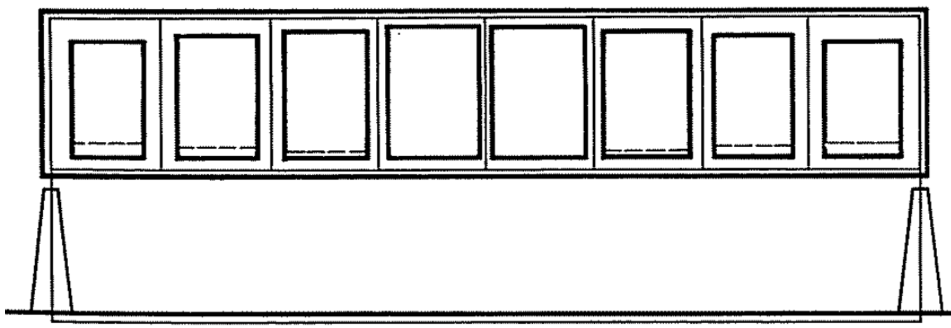
Infolge Durchbiegung der Riegel werden die Enden der Stiele mitgedreht und zwar oben in entgegengesetzter Richtung wie unten. Dadurch wird die Drehung im Stiel aufgenommen und Durchbiegung eingeschränkt. Wirksamkeit erhöht sich mit Anzahl der Stiele (Felder)

due to bending deflection of beams, the ends of columns will be rotated, the upper end in opposite direction from the lower end. thus rotation will be resisted by the column and deflection is obstructed. efficiency will increase with number of columns (panels)

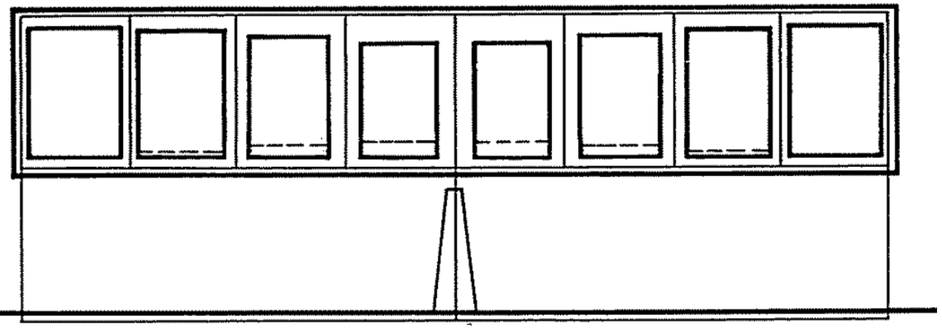
RELATIONSHIP BETWEEN PANEL DESIGN AND MECHANISM OF MULTI-PANEL FRAME (1/2)



RELATIONSHIP BETWEEN PANEL DESIGN AND MECHANISM OF MULTI-PANEL FRAME (2/2)

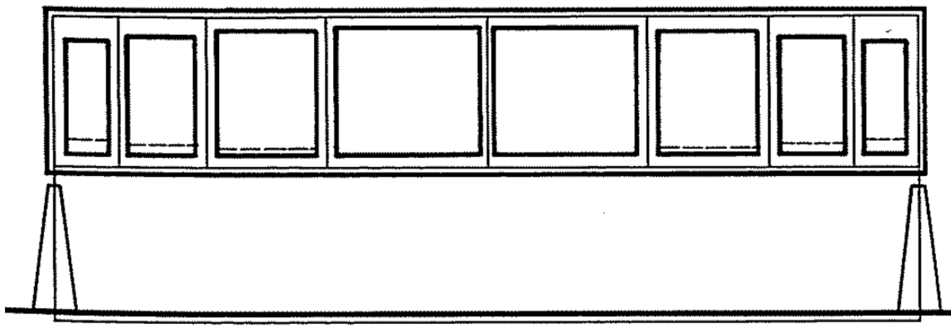


typische Tragwerkform
typical structure form

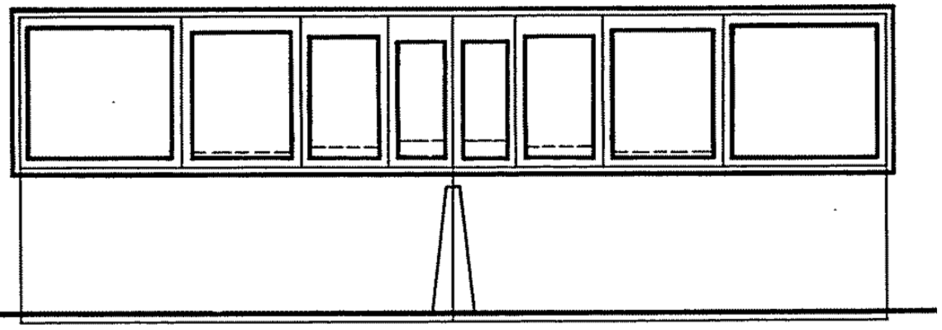


Verbreiterung der Stiele nach den Auflagern zu bei gleichgroßen Feldbreiten

increase of column section toward supports at regular column spacing



typische Tragwerkform
typical structure form



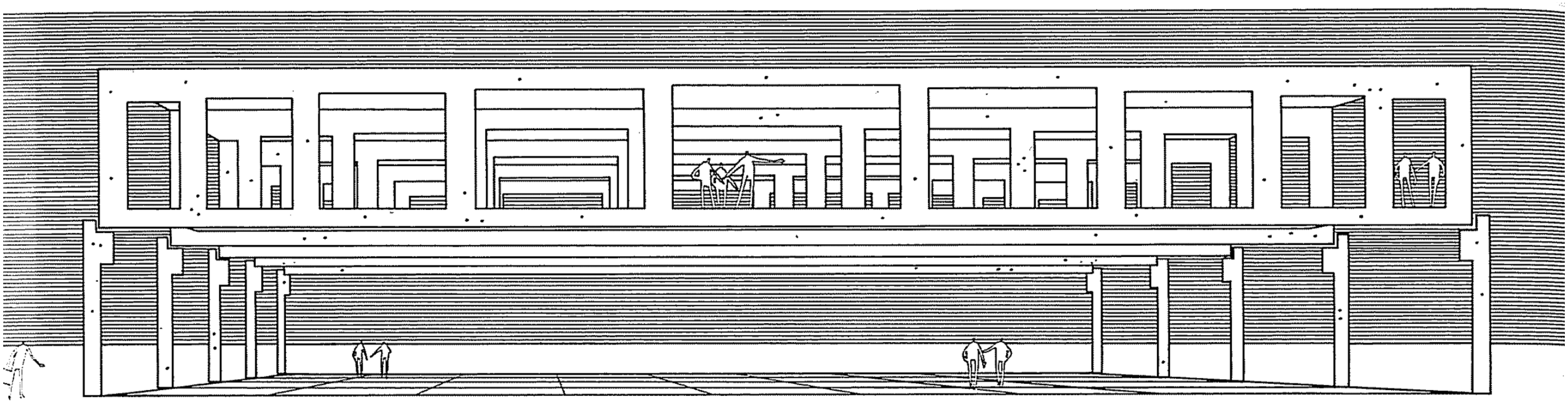
Verkleinerung der Felder nach den Auflagern zu bei gleichbleibenden Stielen

reduction of panel width towara supports with columns of same section

Entsprechend der Scherkraftverteilung im Vollträger, werden die Stiele sehr unterschiedlich auf Biegung beansprucht. Dem Unterschied kann durch Verkleinerung der Felder nach dem Auflager zu oder durch Verbreiterung der Stiele entsprochen werden

according to shear distribution in a beam the columns are subjected to very different degrees of bending. this difference can be integrated by reduction of panel width toward supports or by increase of column section

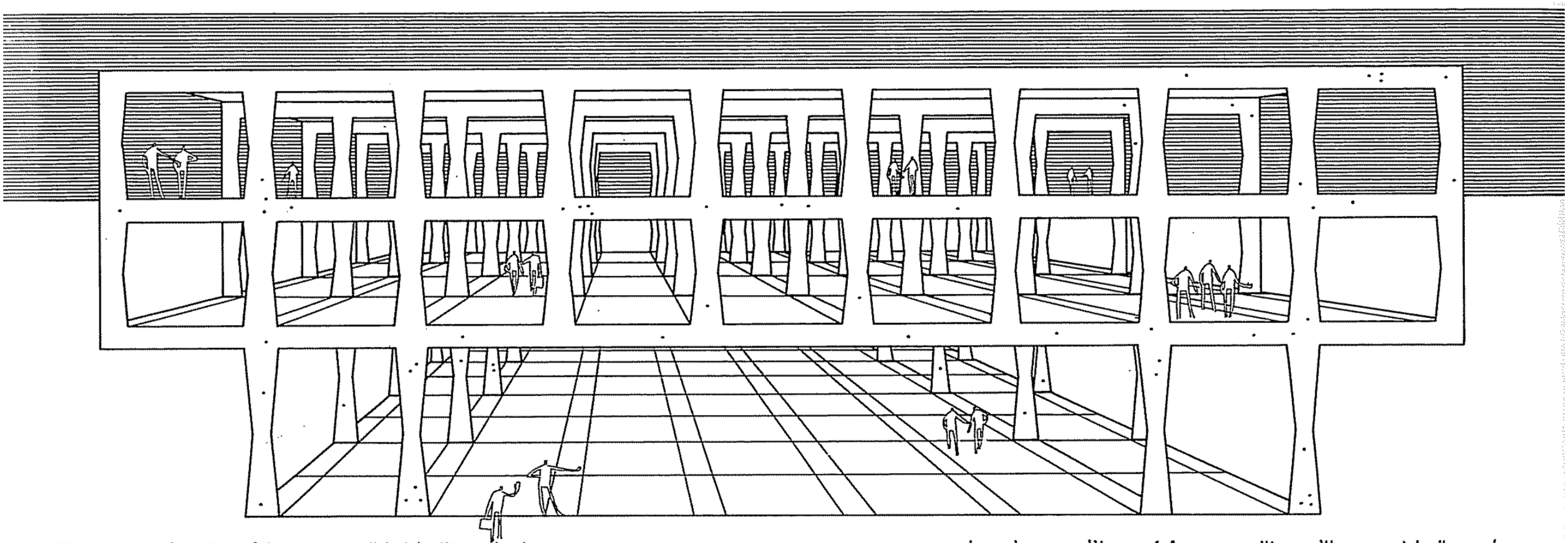
LONG-SPAN STRUCTURE SYSTEMS COMPOSED OF MULTI-PANEL FRAMES (1/3)



Eingeschossiger Mehrfeldrahmen auf zwei Stützen

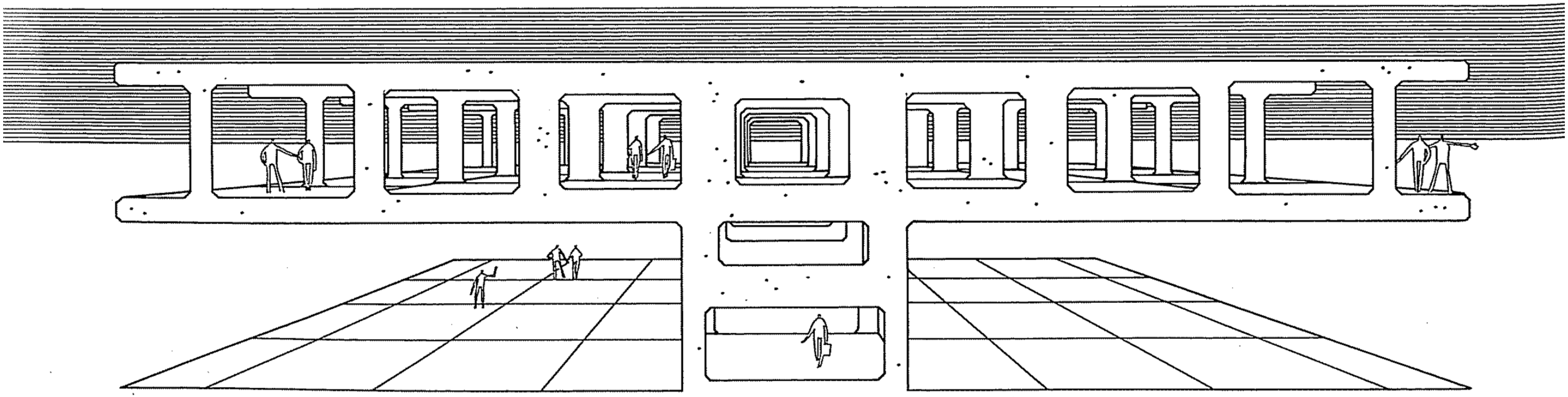
single-story multi-panel frame supported at both ends

LONG-SPAN STRUCTURE SYSTEMS COMPOSED OF MULTI-PANEL FRAMES (2/3)



Zweigeschossiger Mehrfeldrahmen mit beidseitiger Auskragung

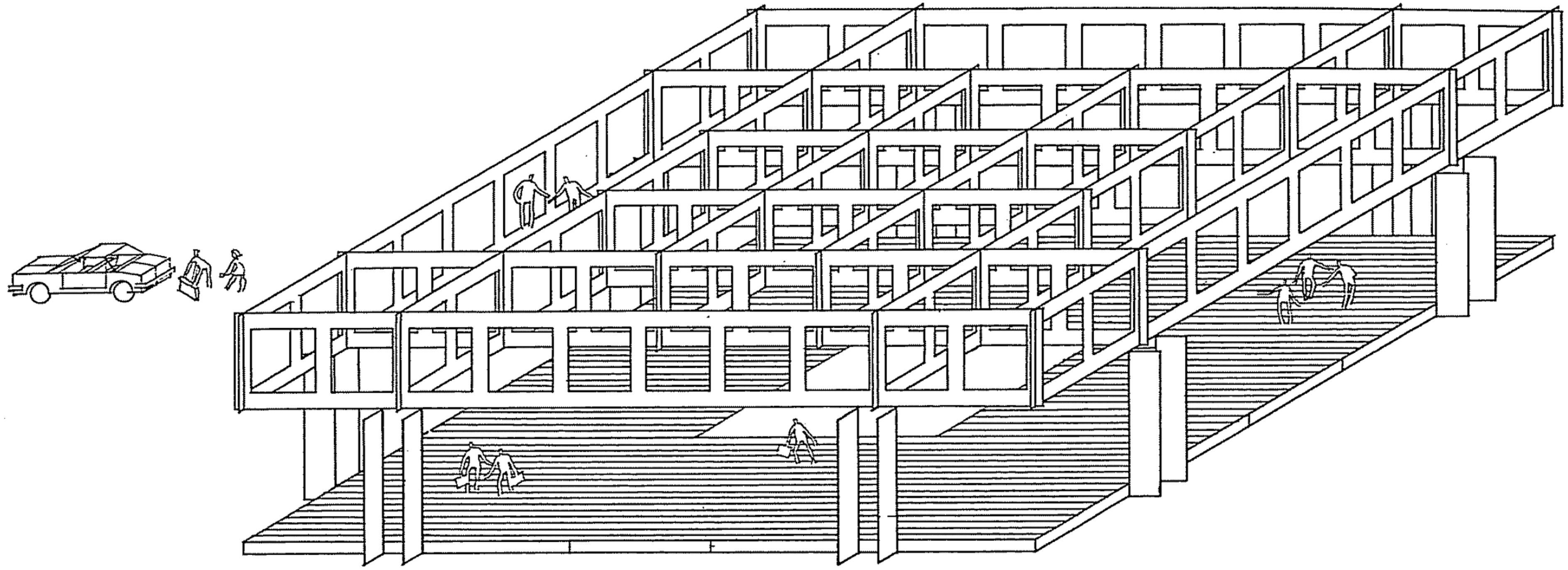
two-story multi-panel frame with cantilevers at both ends

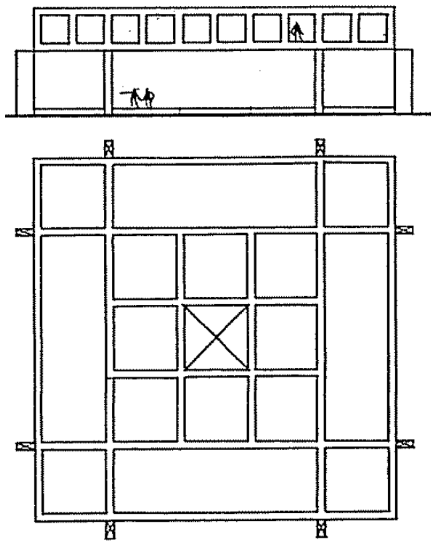


Eingeschossiger Mehrfeldrahmen auf Mittelstützen

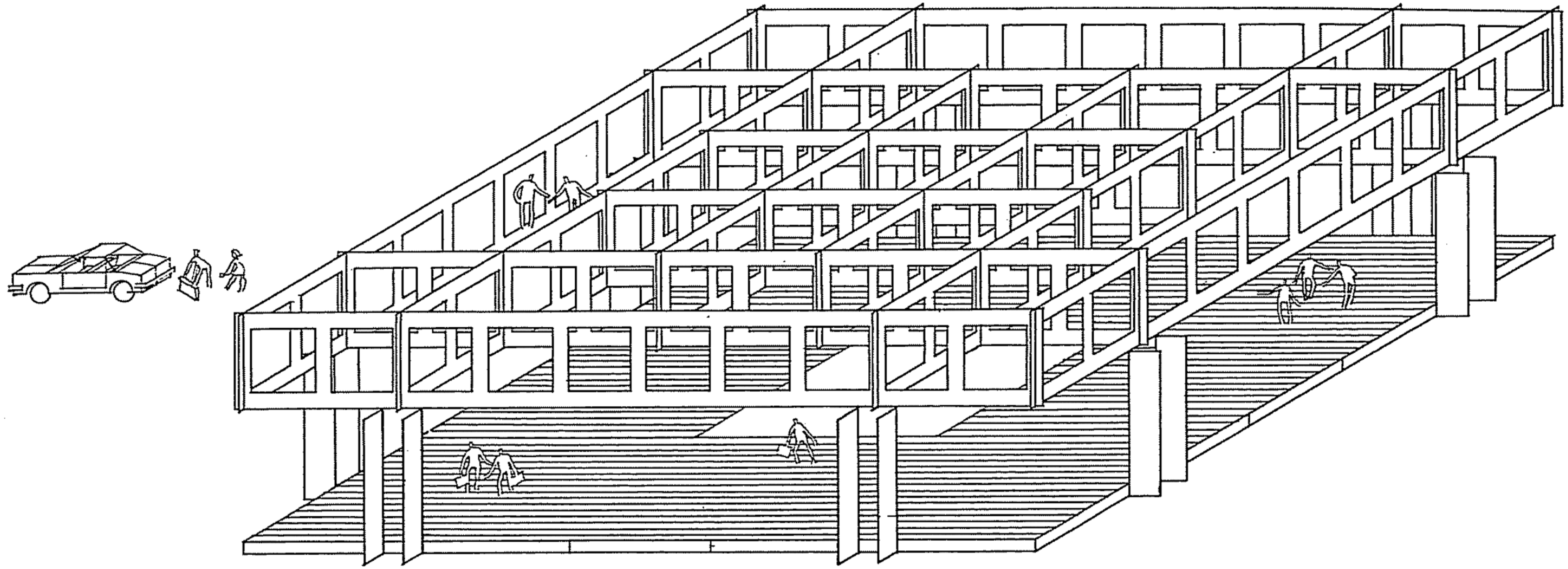
single-story multi-panel frame on central-supports

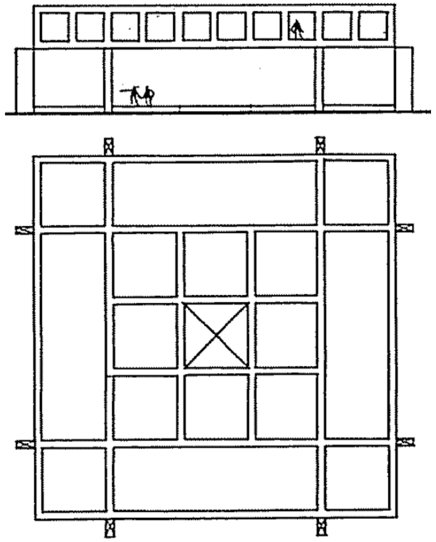
▶ Concentric grid from multi-panel frames



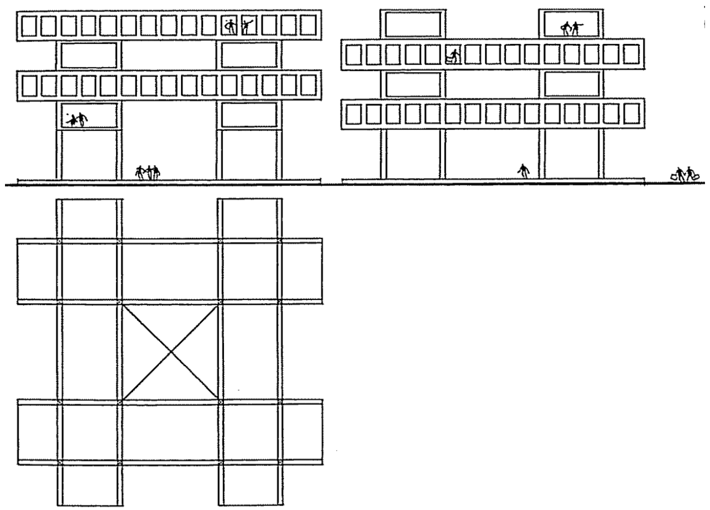


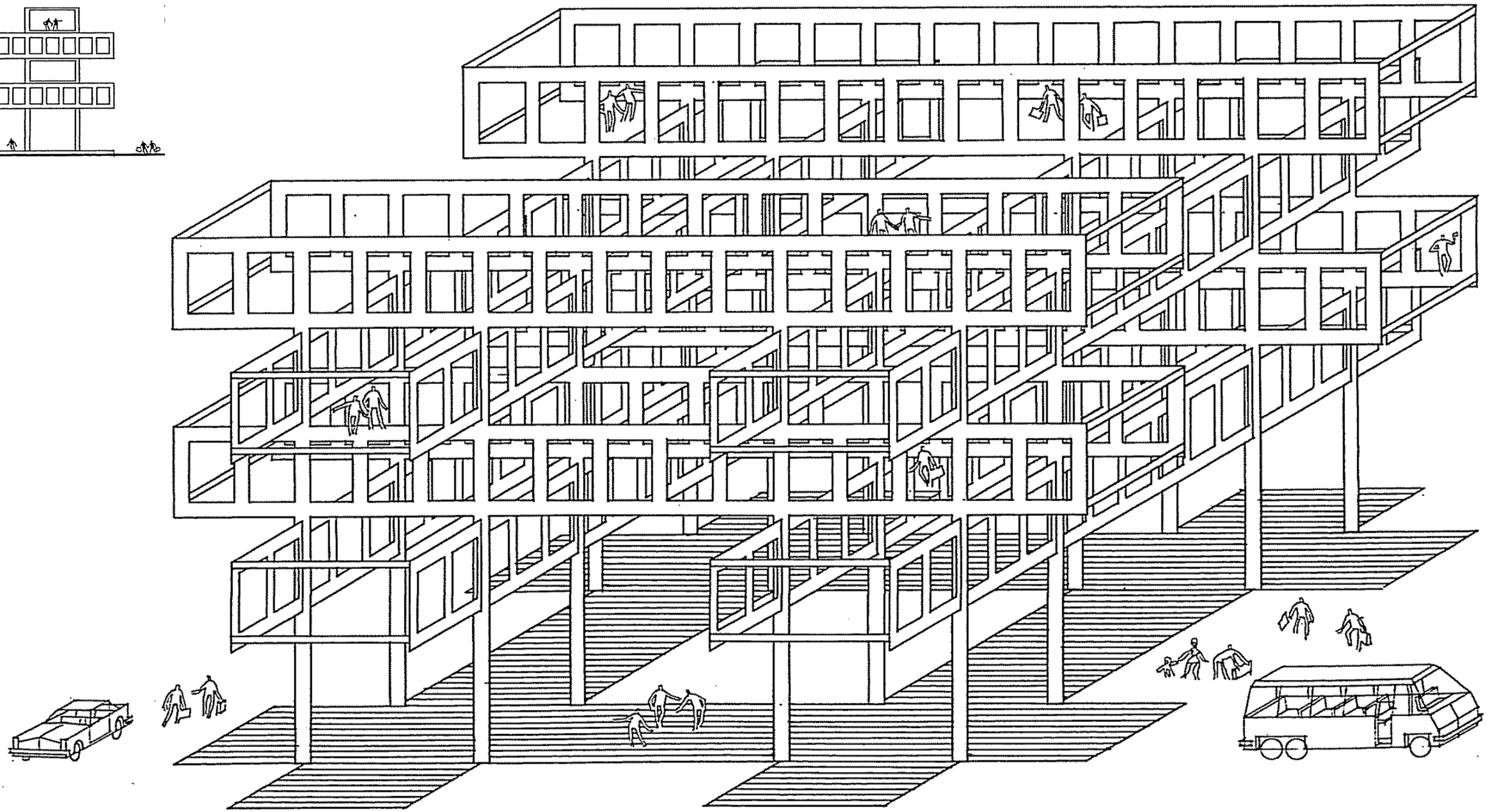
- Concentric grid from multi-panel frames



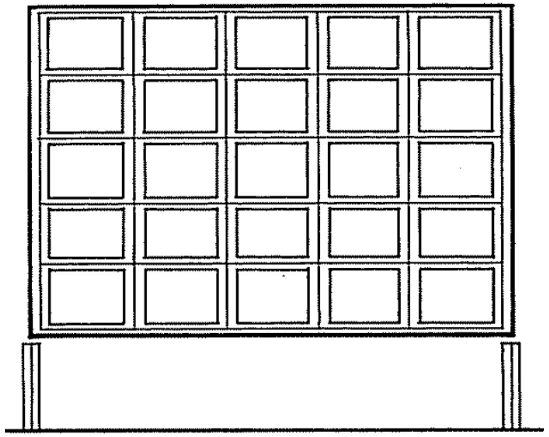


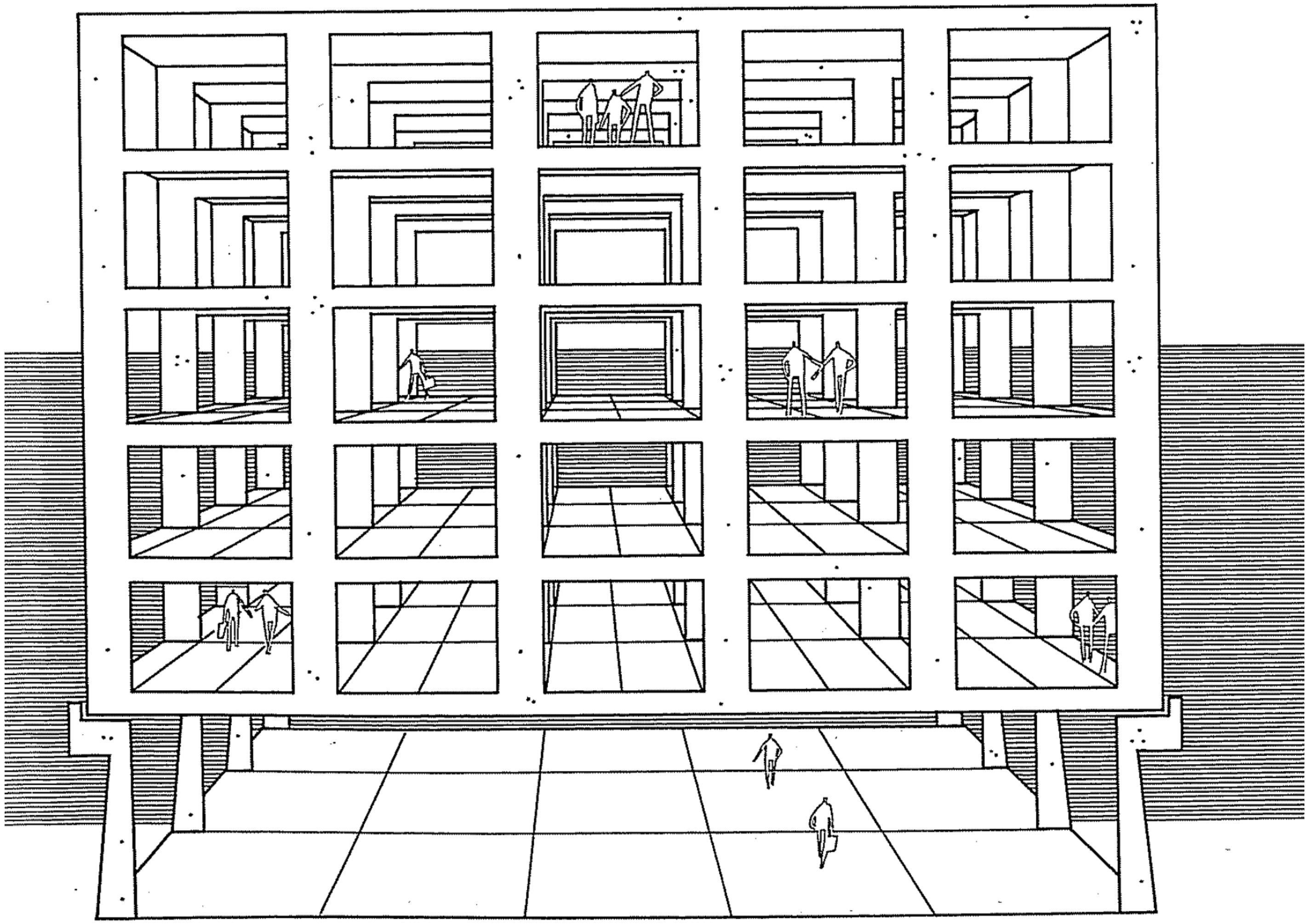
- Two-way stacking of multi-panel full frames



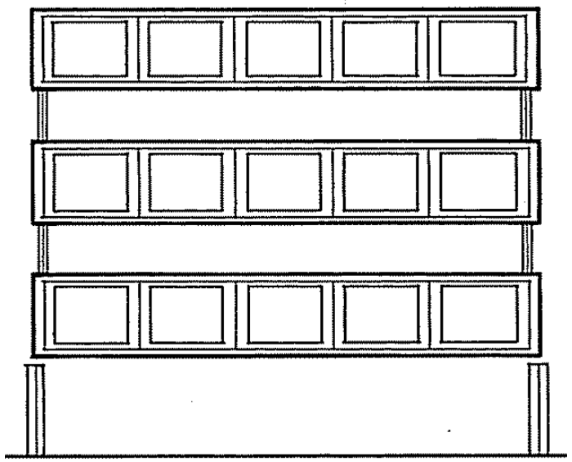


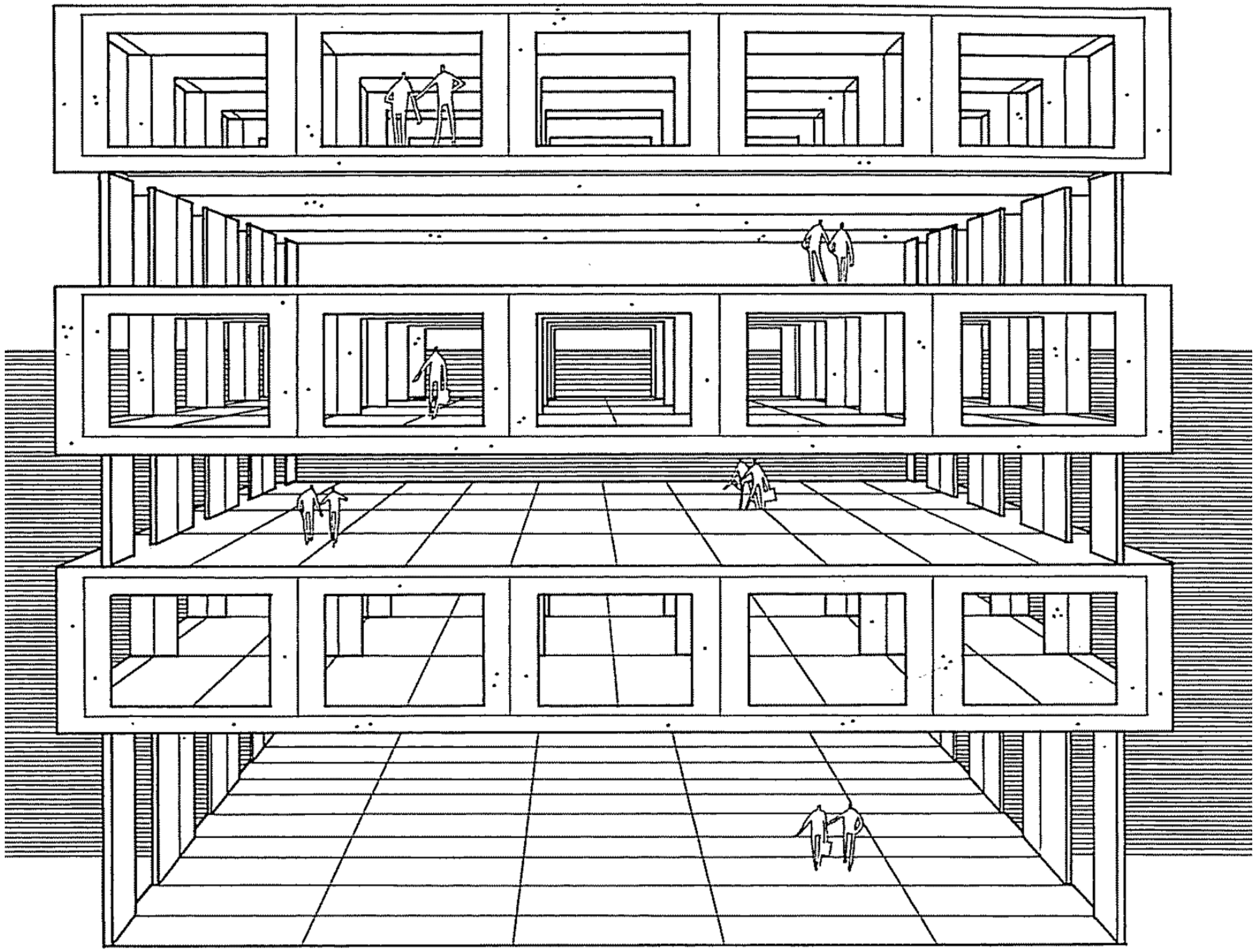
- Multi-panel frame continuous through all floors



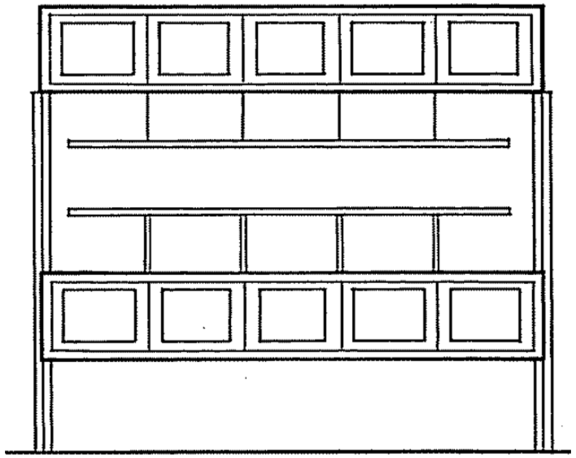


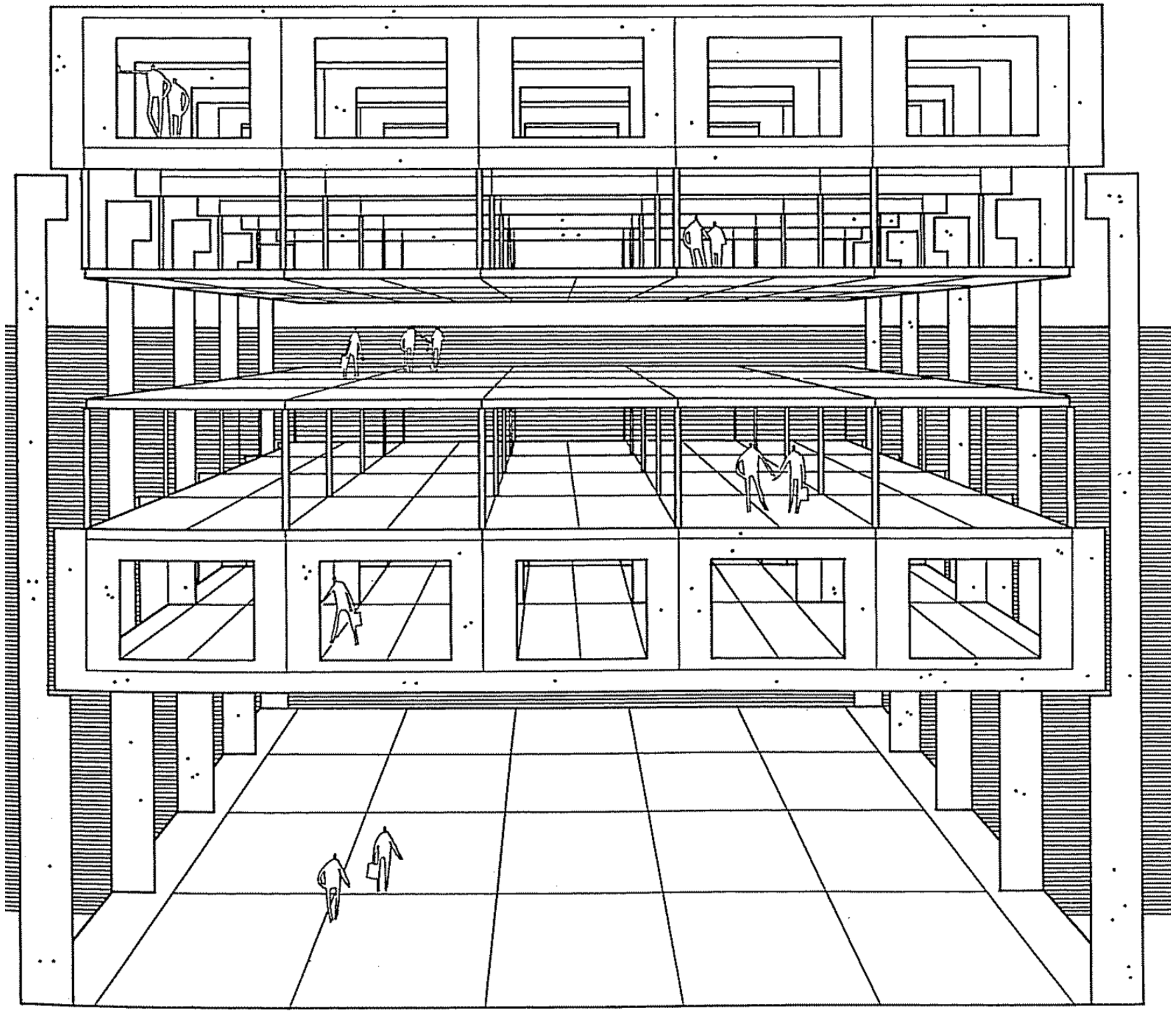
▶ Single-story multi-panel frame as support for each two floors



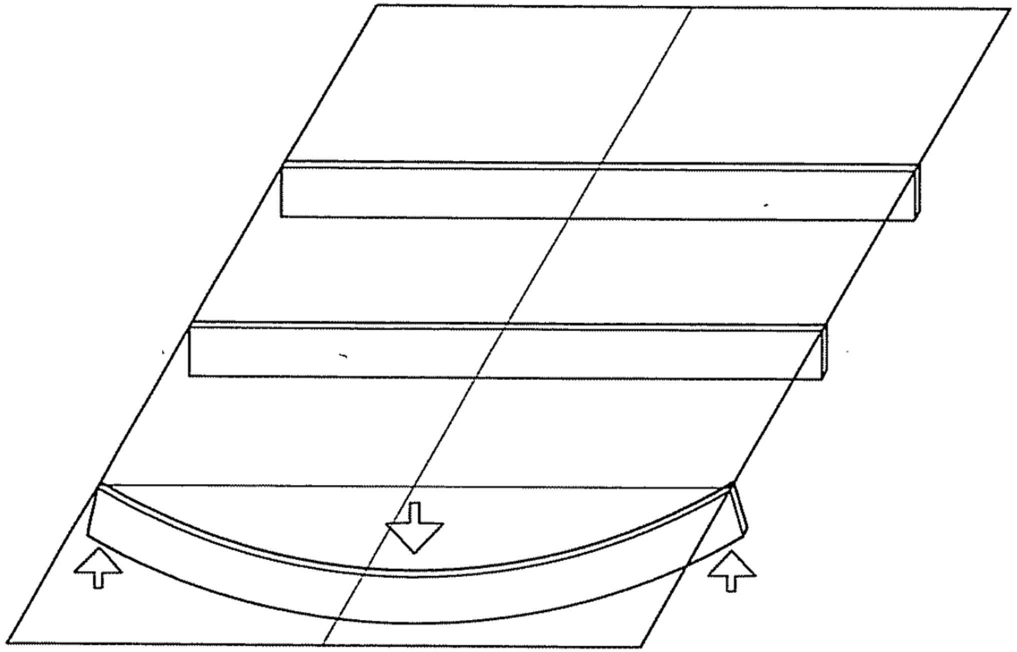


▶ Single story multi-panel frame as support for each three floors



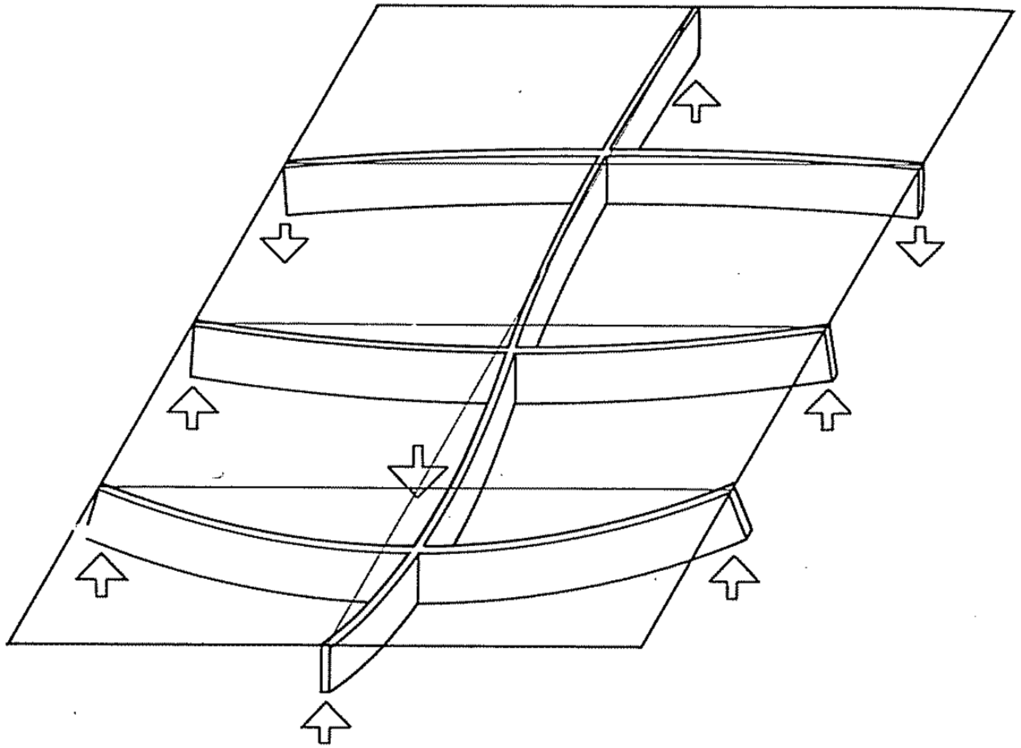


▶ Biaxial load dispersal



Im Parallelträger-System wird jeweils nur der von der Einzellast betroffene Träger deformiert. Die übrigen Parallelträger nehmen nicht an Widerstandsmechanismus gegen Einzellast teil.

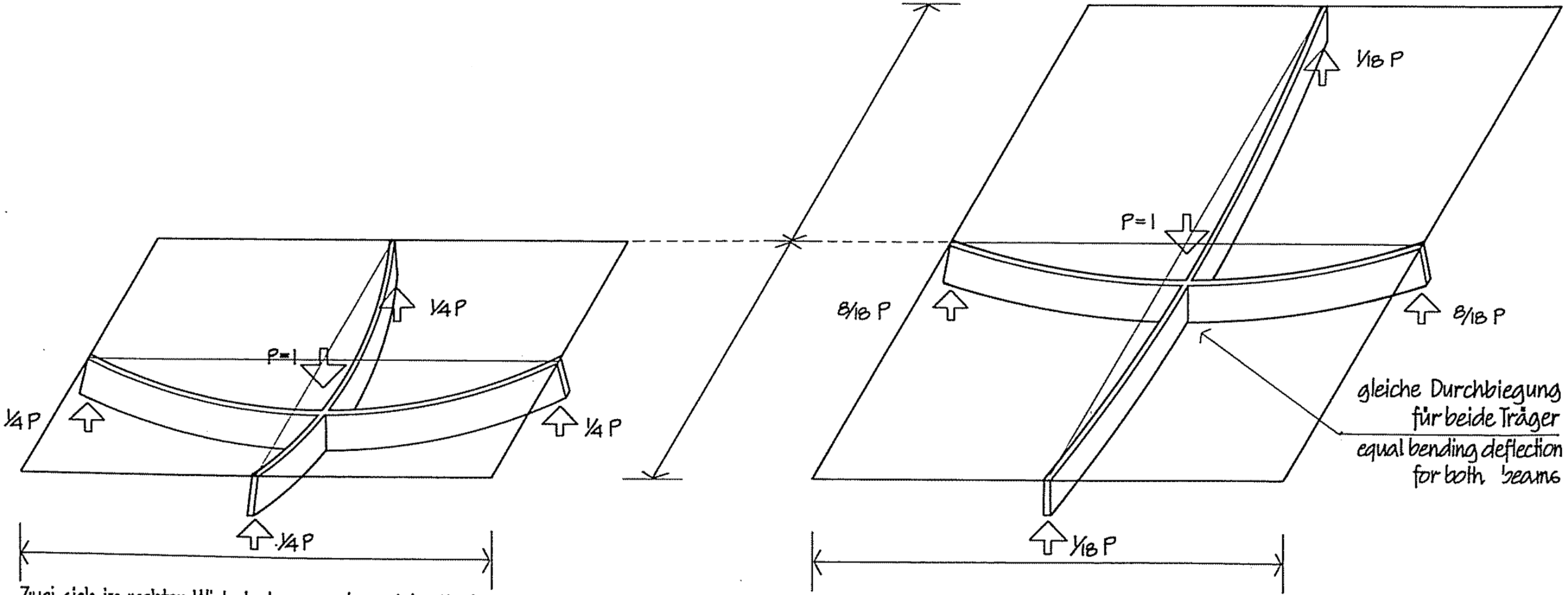
in the parallel beam system only the one beam under load will be deflected. the other parallel beams do not participate in the resistance mechanism against single load.



Durch Einfügen eines im rechten Winkel zu den Parallelträgern laufenden Querträgers wird ein Teil der Last auf die anderen Parallelträger abgetragen Das gesamte System nimmt am Widerstandsmechanismus gegen Einzellast teil.

through insertion of a transverse beam at right angles to the parallel beams one part of the load is transmitted to the beams not directly loaded. thus the entire system is participating in the resistance mechanism against single load

INFLUENCE OF SIDE PROPORTIONS UPON MAGNITUDE OF BIAXIAL LOAD DISPERSAL

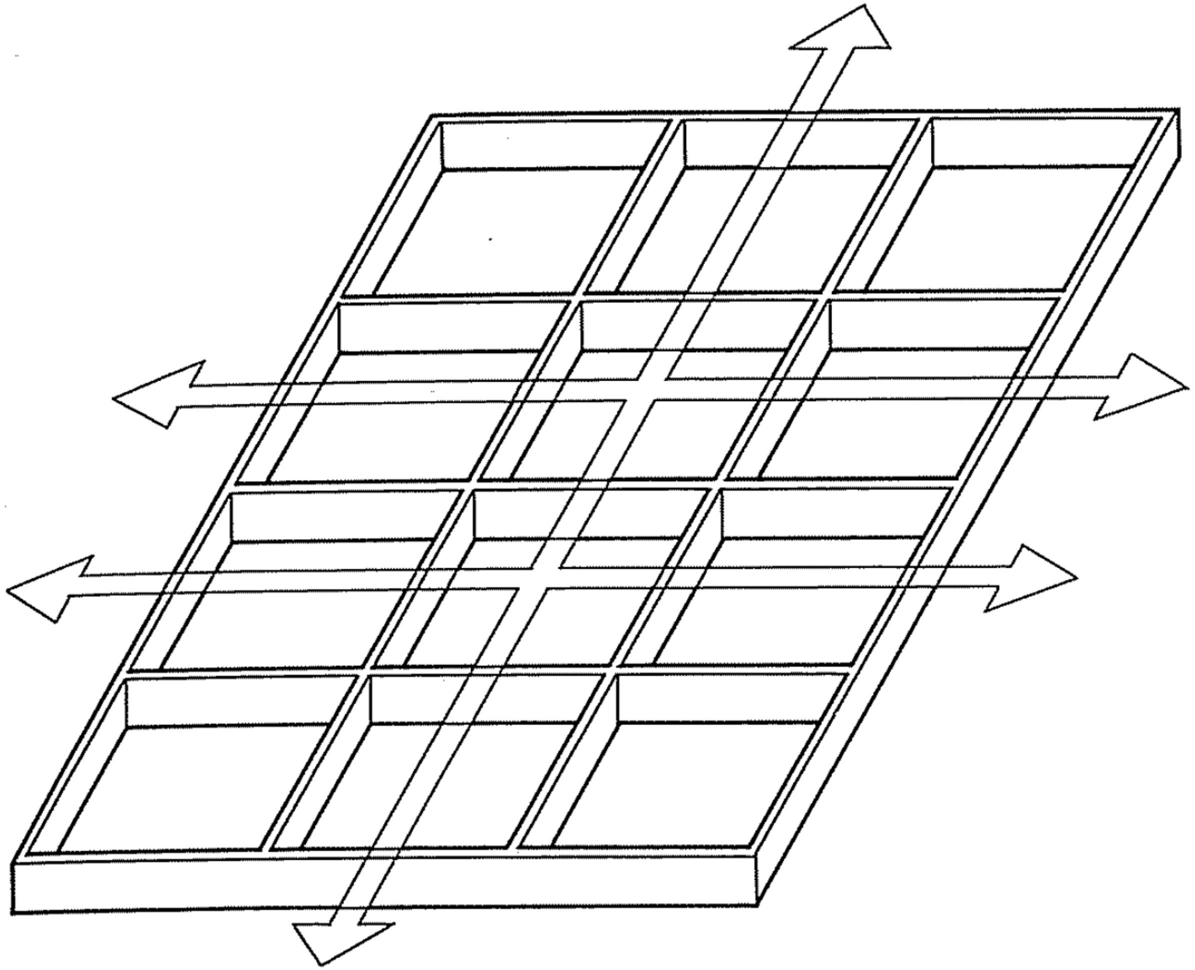


Zwei sich im rechten Winkel kreuzende identische Balkenträger tragen je die Hälfte der Einzellast ab. Also ergeben die Auflagerkräfte je ¼ der Gesamtlast

two identical beams at right angles to each other receive each one half of the total load. consequently each support reaction equals ¼ of the total load

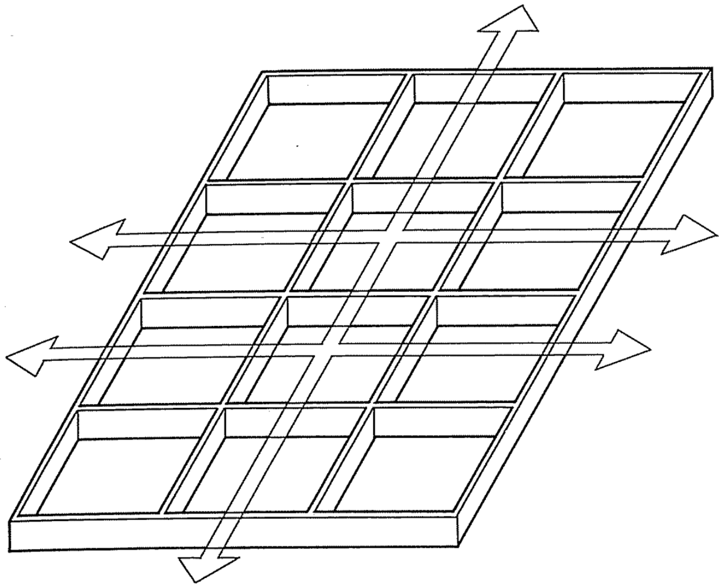
Bei Balkenträgern gleichen Querschnittes jedoch verschiedener Länge wird der steifere (weil kürzere) von beiden Trägern die Hauptlast tragen. Bei Seitenverhältnis 1:2 wird sich Steifigkeit der Träger wie 1:8 verhalten. Der kurze Träger nimmt also 8/9 der Last.

if beams of same section have different length, the stiffer (because shorter) beam takes most of the load. if the ratio of the sides is 1:2, the stiffness of beams will have a ratio of 1:8. hence the shorter beam receives 8/9 of the total load.

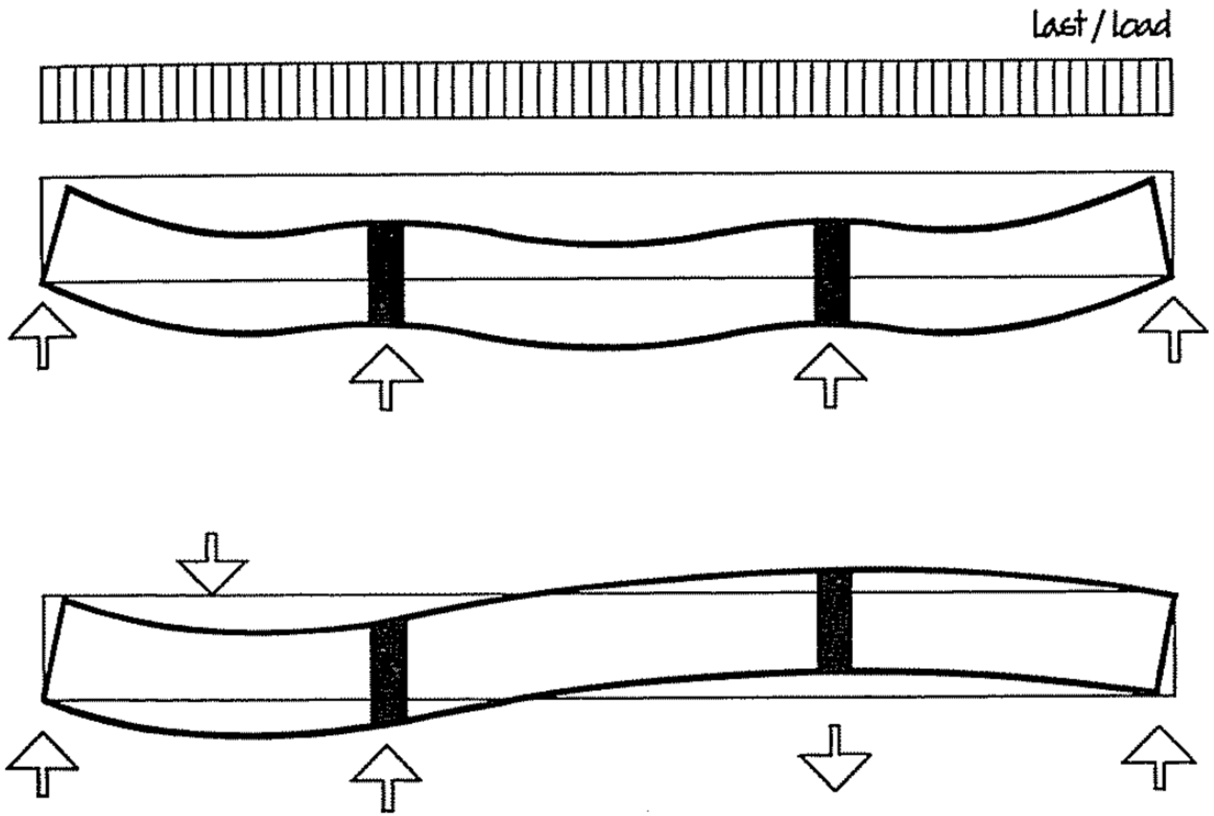


Vorausgesetzt daß beide Trägerreihen annähernd gleiche Steifigkeit haben, wird Last durch Biegemechanismus jeweils in zwei Achsen abgetragen. Bei Einzellasten werden wegen der gegenseitigen Durchdringung auch die nicht direkt belasteten Träger deformiert. Dadurch wird Widerstandskraft erhöht.

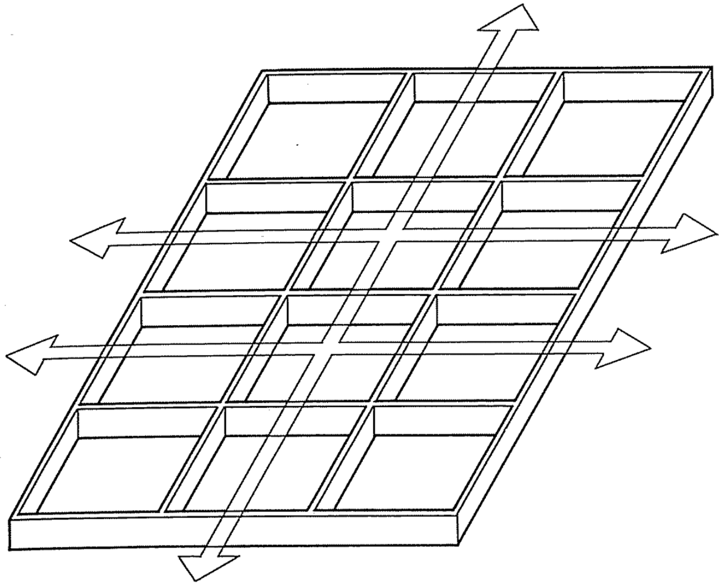
provided that both sets of beams have approximately equal stiffness, load is dispersed by bending mechanism in two axes. in the case of a point load condition, due to mutual interpenetration also the beams not directly under load deflect. consequently bending resistance is increased.

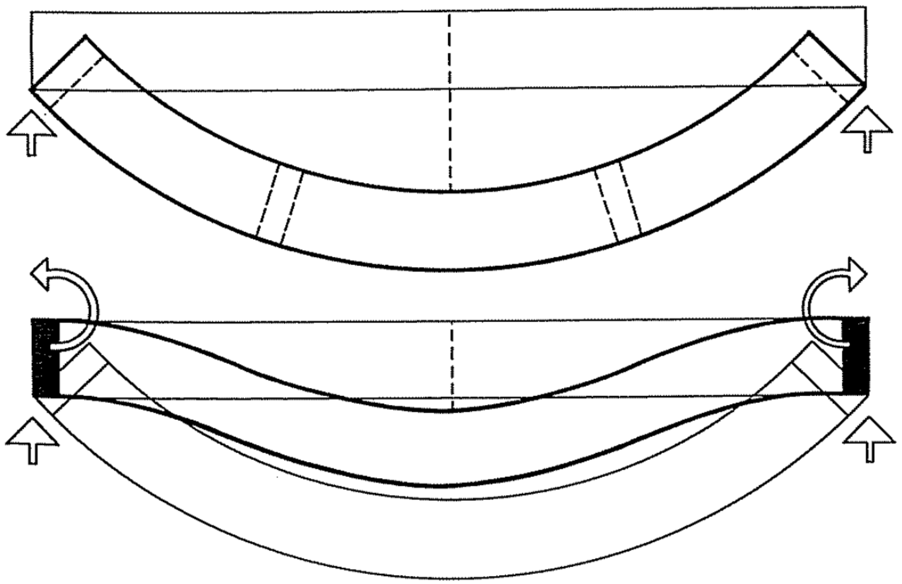


the single beam in the beam grid acts as a continuous beam. of which the intermediate supports are flexible under one-sided loading a reversal of bending deflection (=negative bending) can occur.

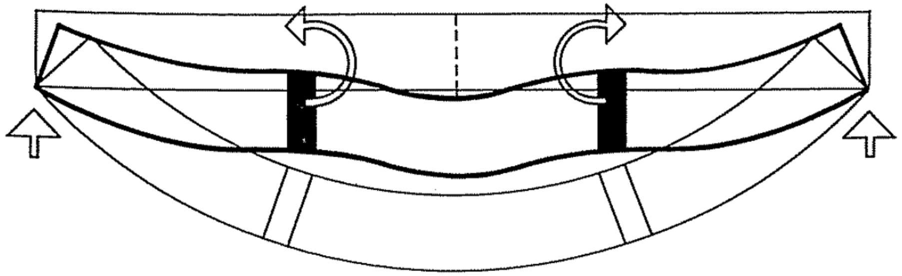


ADDITIONAL BEARING ACTION THROUGH RESISTANCE AGAINST TWISTING



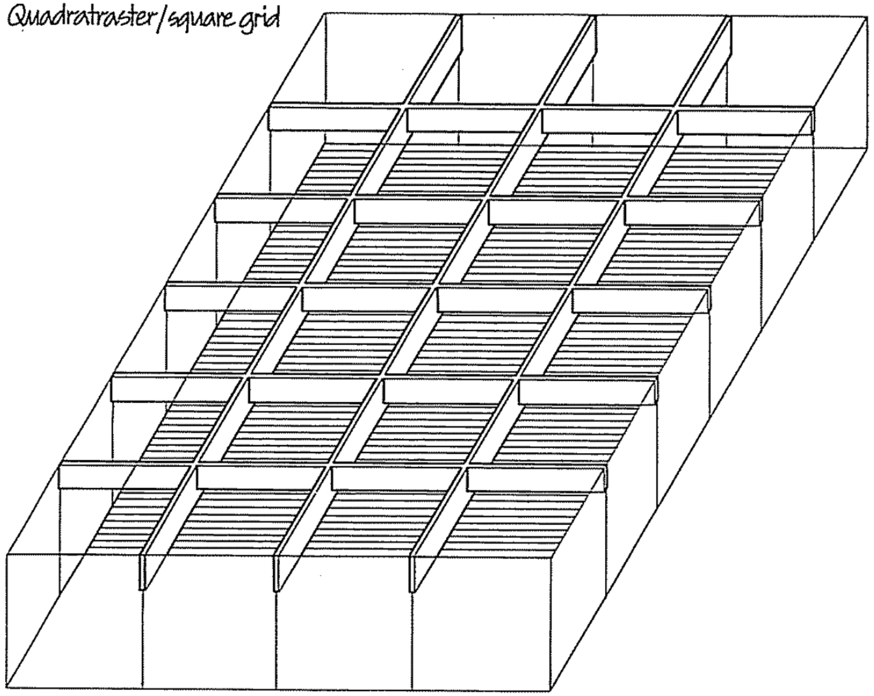


due to rigid intersections the edge beam is twisted by bending rotation of the ends of the transverse beam. resistance against twisting by the edge beam has effect of a fixed-end situation. it reduces bending of cross beam

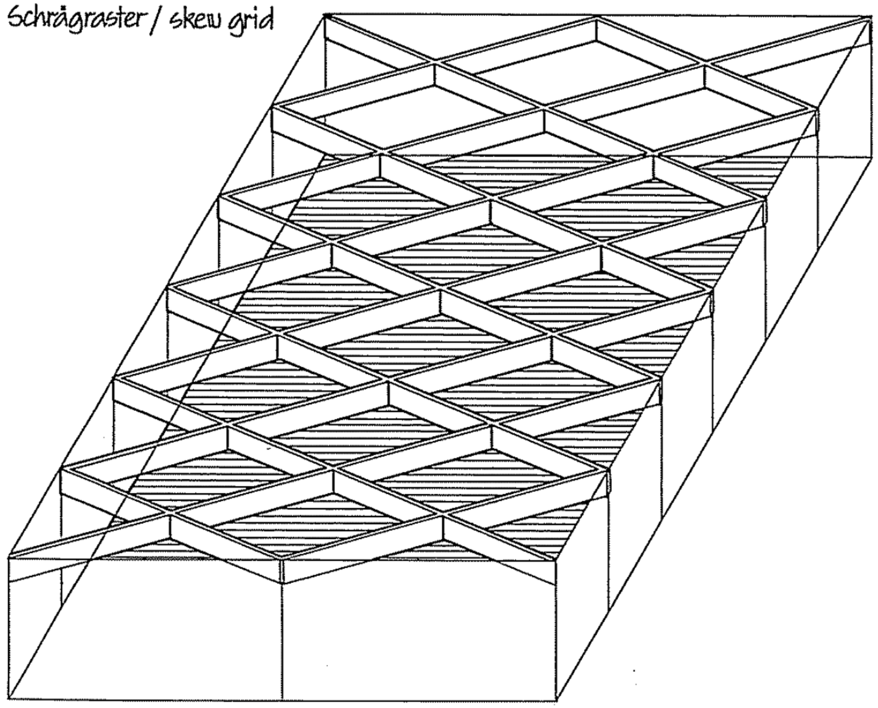


due to rigid intersections the bending deflection of one beam section causes the twisting of the beam section running crosswise. through this another resistance mechanism against bending deflection is activated

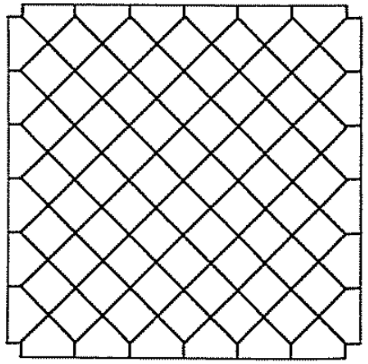
BEAM GRIDS FOR FLOOR PLANS WITH UNEQUAL SIDES

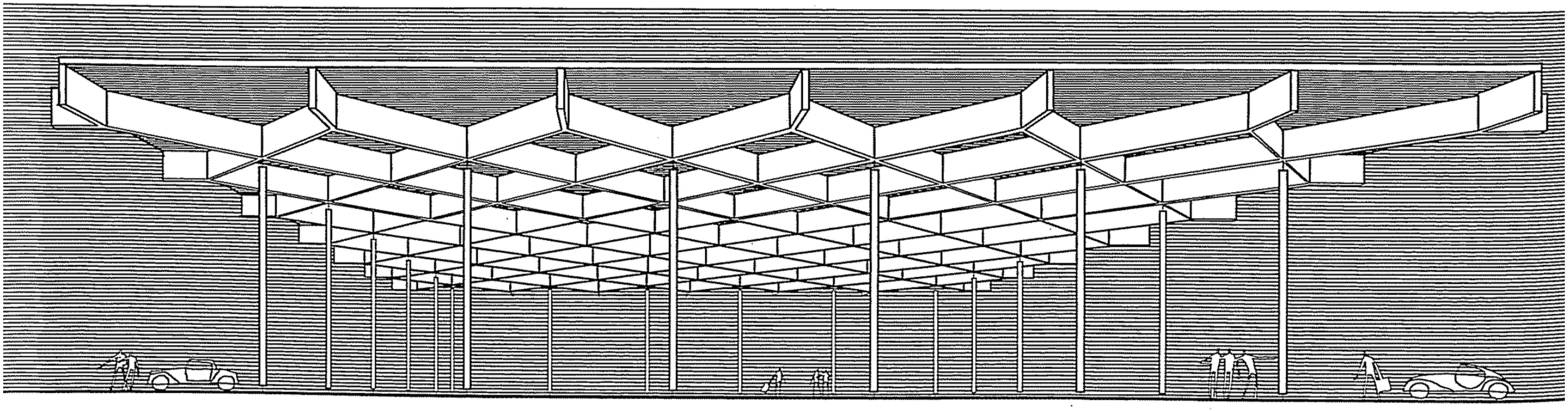


in rectangular floor plans of which one side is markedly longer than the other the longitudinal beams due to diminished stiffness show loss of efficiency. in order to allow equal load dispersal in two axes, the long beams must be stiffened accordingly, i.e. if plan has ratio of 1:2, long beams must be eight times stiffer



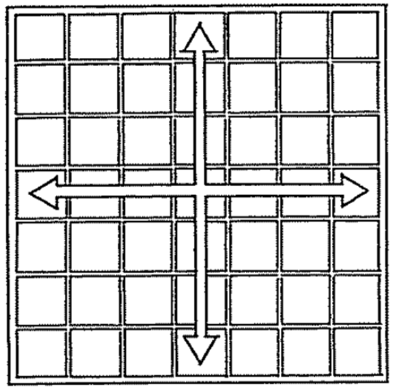
the skew grid avoids the disadvantage of unequal bean lengths in oblong floor plans. moreover because of shorter beam spans at the corners additional stiffness is achieved much like in a fixed end condition



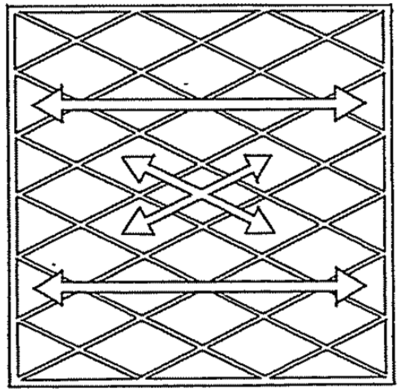


- Aside from the fundamental commitment to the configuration of floor plan and to the disposition of supports the design of beam grids is concerned with three form decisions 1) Geometry of beam pattern 2) Grid relationship to lateral space enclosure 3) Consistency of beam grid structure. Accordingly beam grids will be classified and identified as:

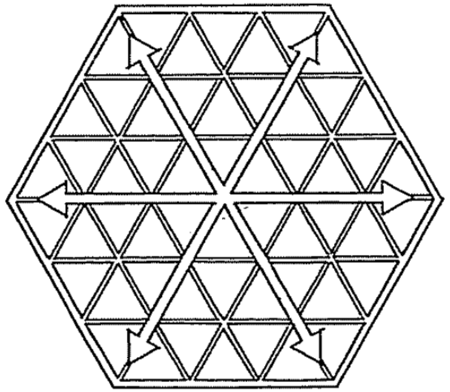
- 1. Standard geometries of beam grids



Orthogonal beam grid
- bi-axial load transfer
- sqare or near-square floor plan with lines of support on all four sides

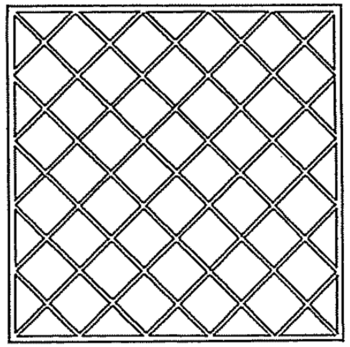


Skewed beam grid
- one-dimensional load transfer
- oblong rectangular floor plan with lines of support on the two opposite sides

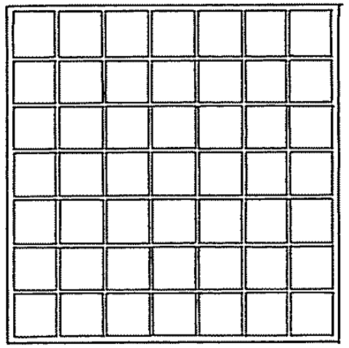


Triangular beam grid
- tri-axial load transfer
- generally concentric floor plan with lines of support on all peripheral sides

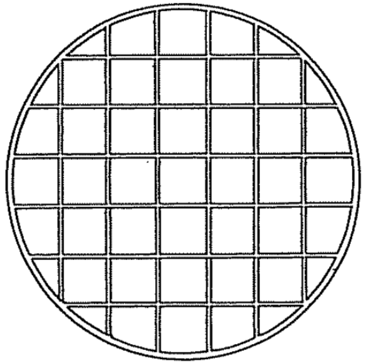
▶ 2. Grid relationship to the lateral space enclosures



Diagonal-Rost / Diagonal beam grid

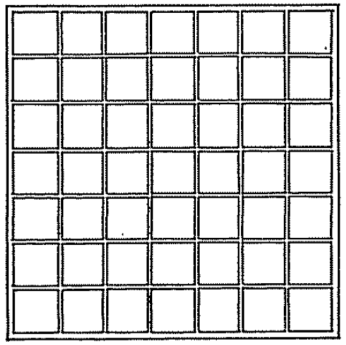


Kongruent-Rost / Congruent beam grid

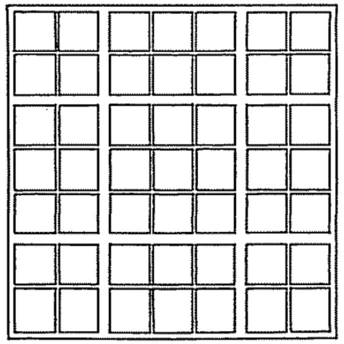


Ausschnitt-Rost / Sectional beam grid

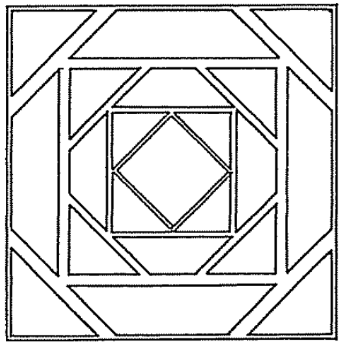
▶ 3. Consistency of beam grid structure



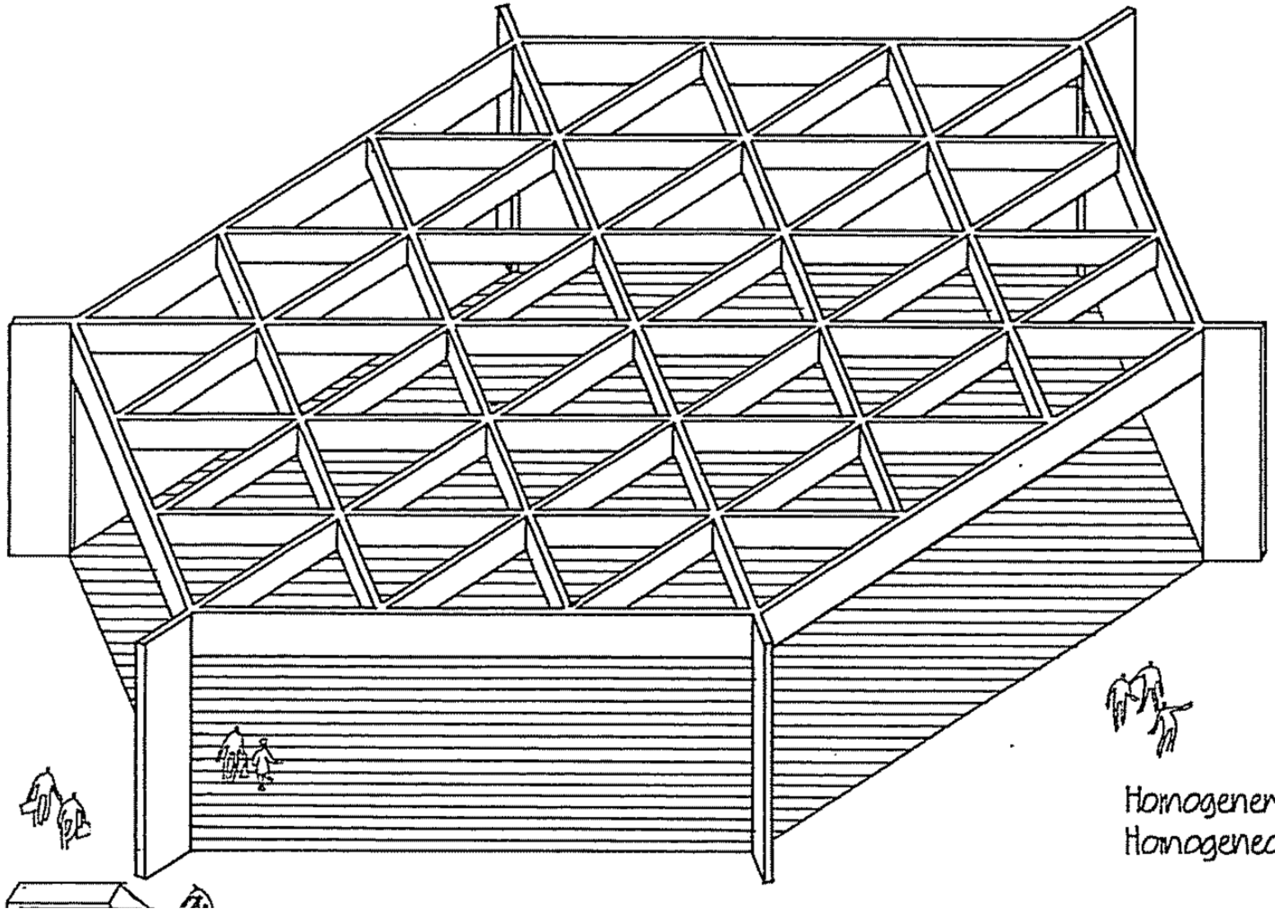
Homogen-Rost: durchläufiges Gefüge
Homogeneous grid: undifferentiated structure

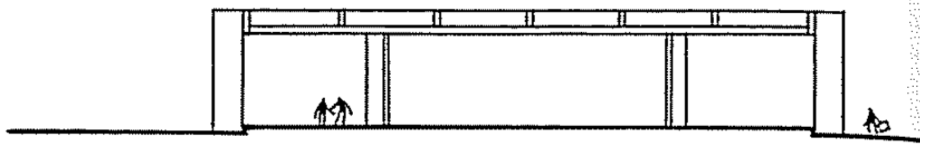


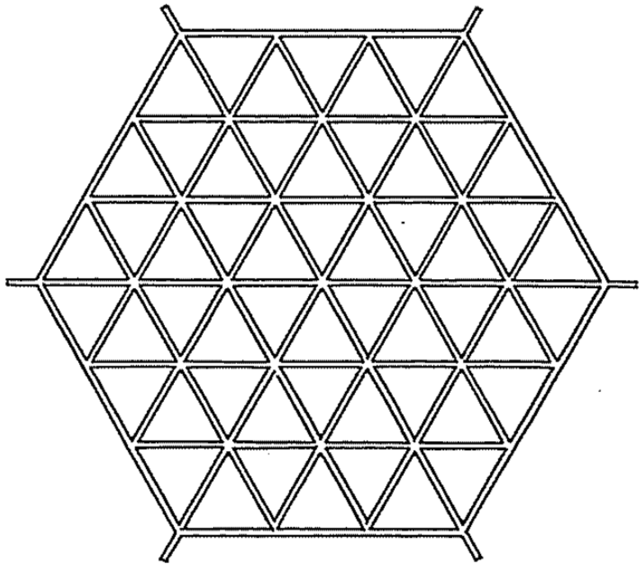
Abgestufter Rost: Haupt- und Nebenrost
Gradated grid: primary and secondary structure



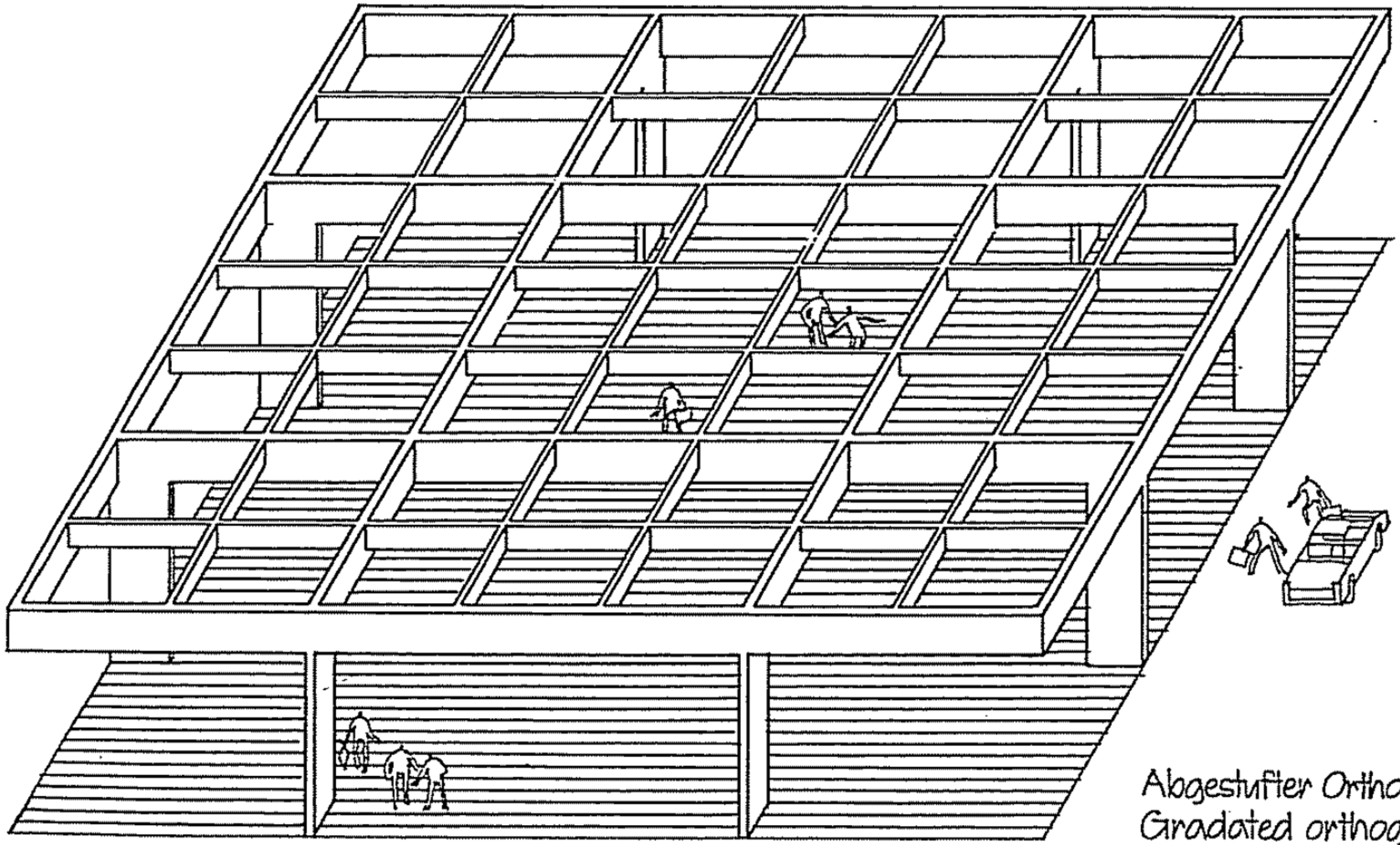
Zentral-Rost: mittig orientierter Rostaufbau
Concentric grid: centralized order of structure



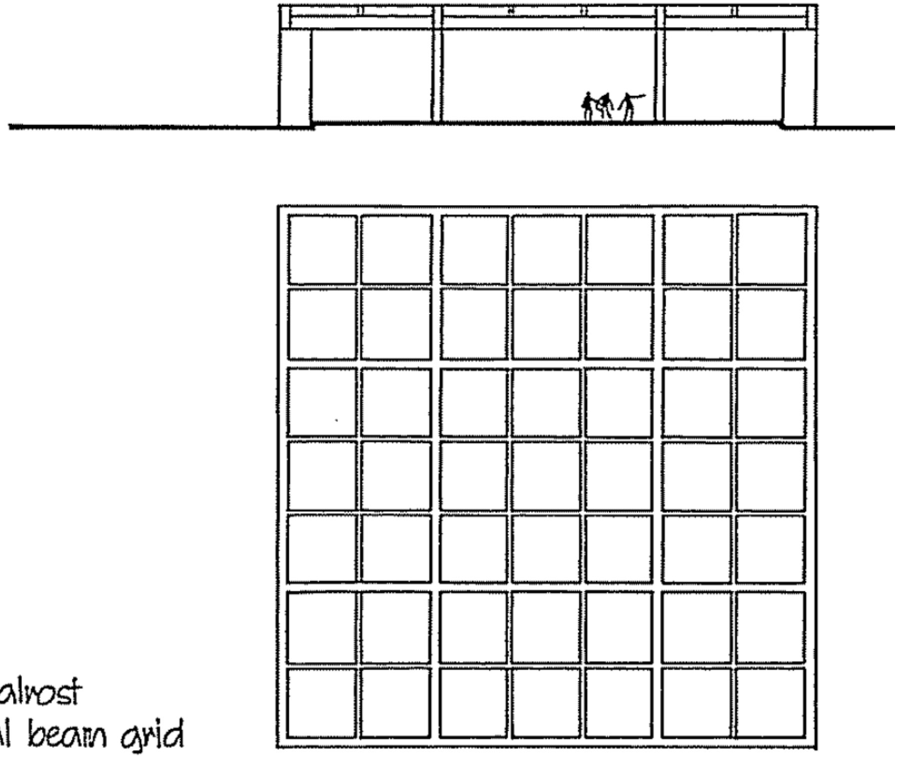


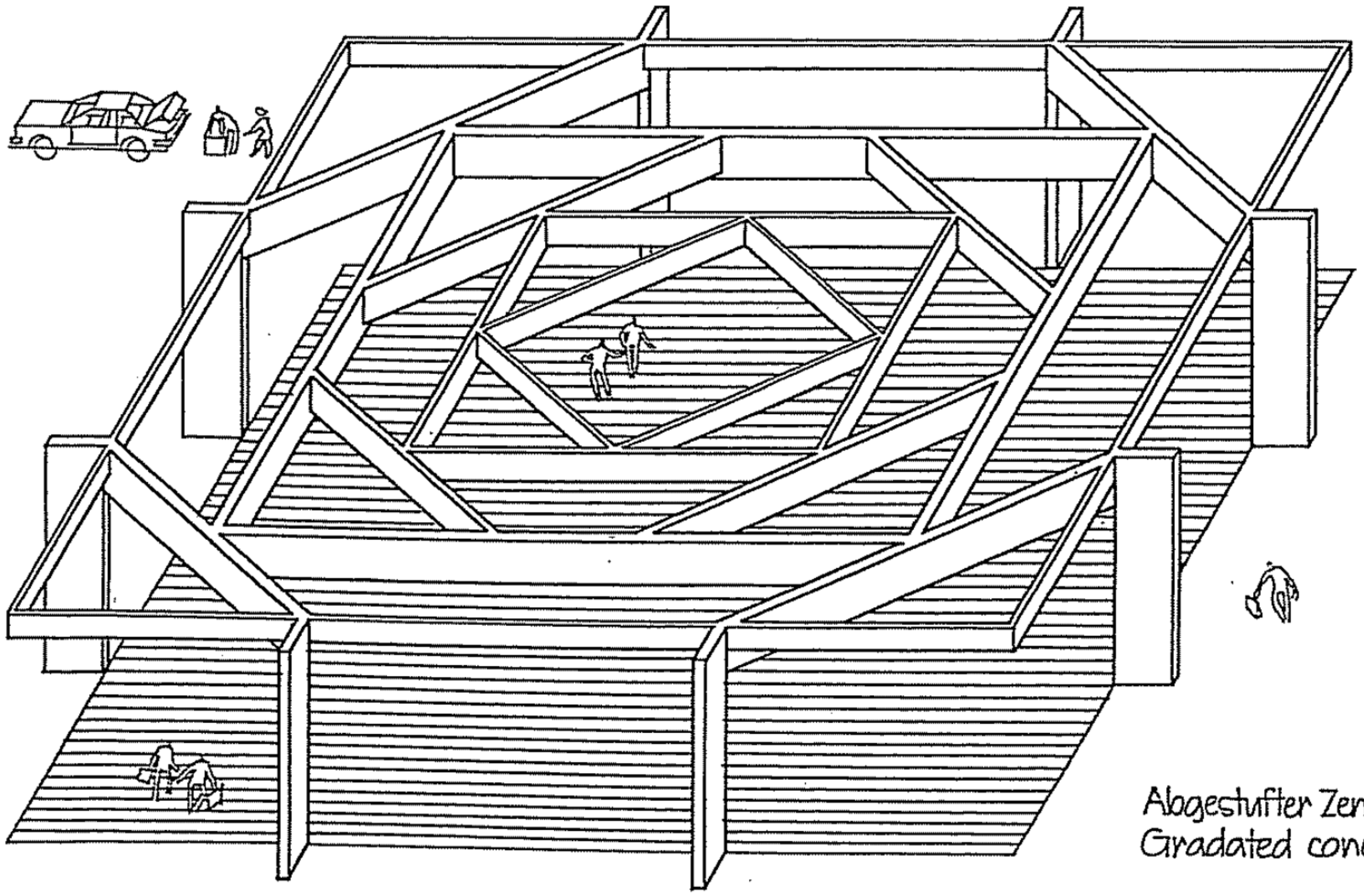


Homogener Dreieck-Rost
Homogeneous triangular beam grid

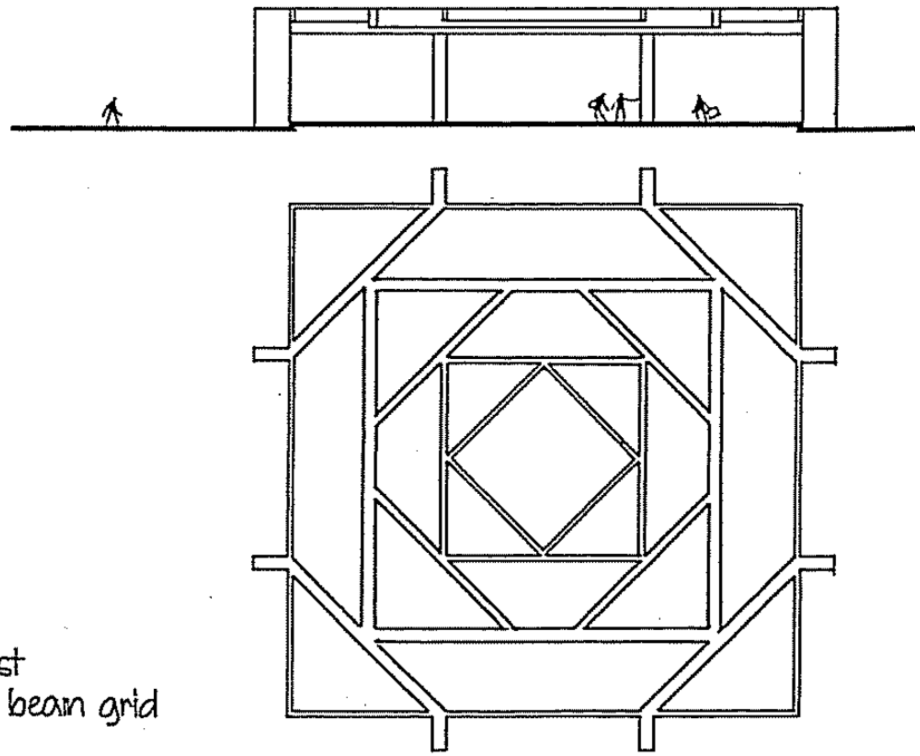


Abgestufter Orthogonalrost
Gradated orthogonal beam grid

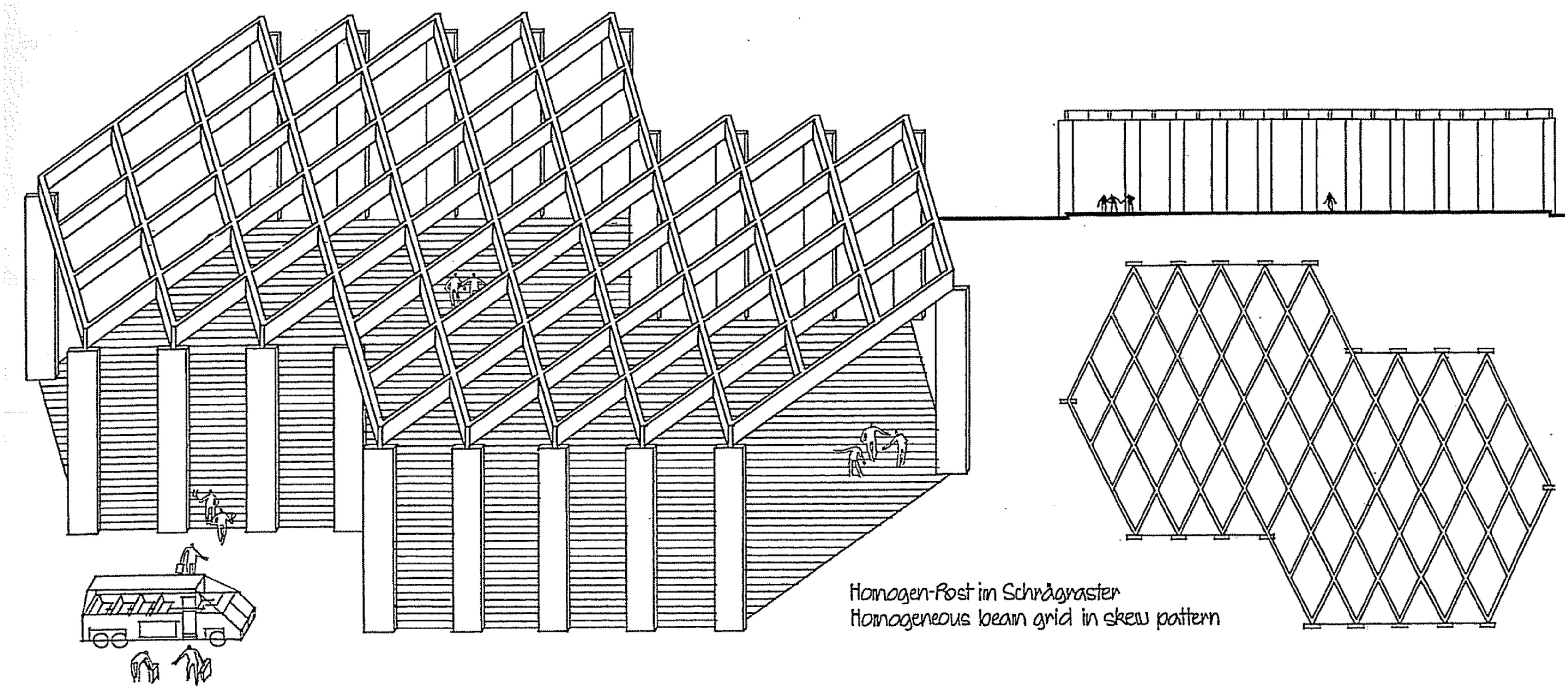




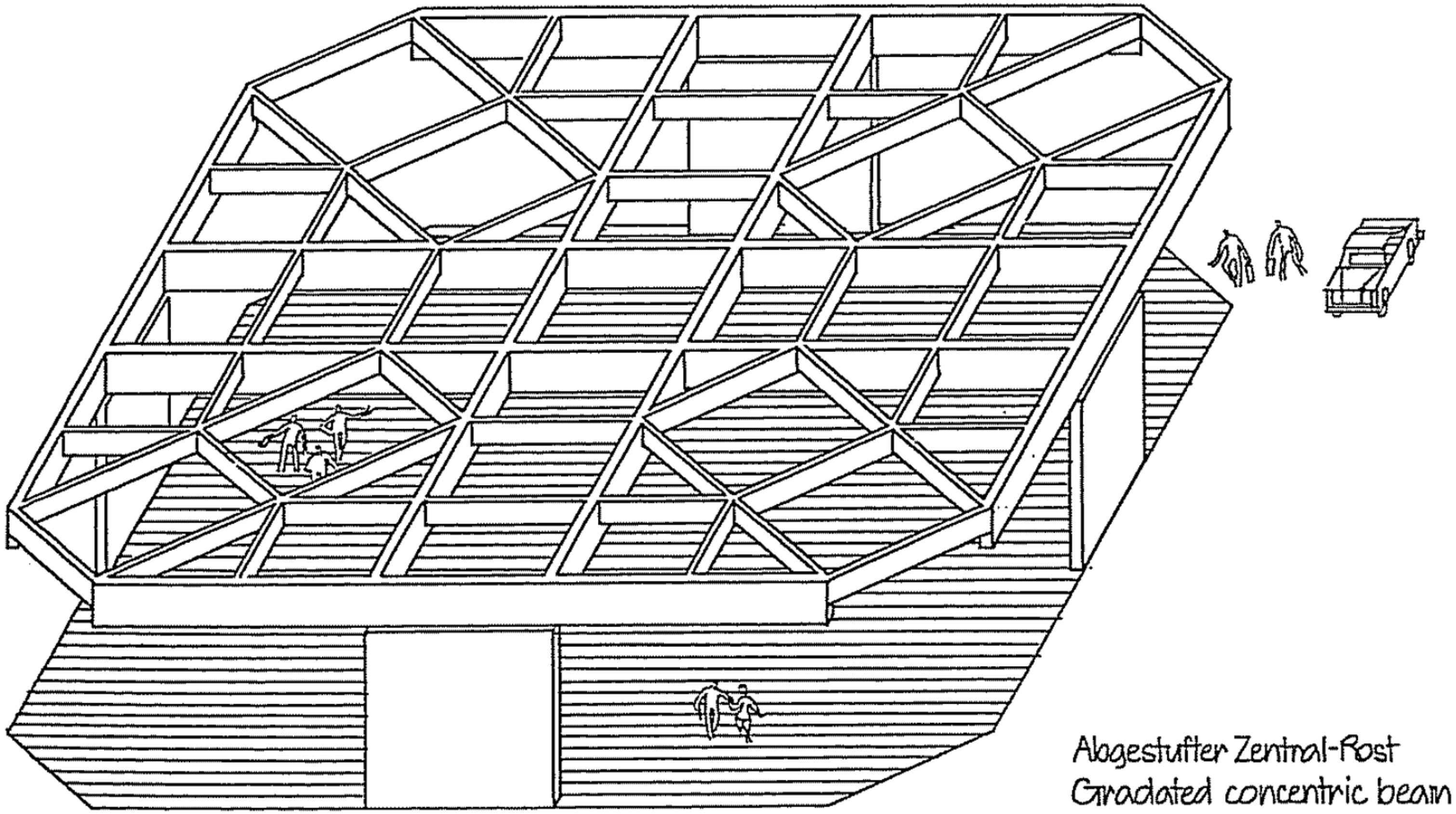
Abgestufter Zentralrost
Gradated concentric beam grid



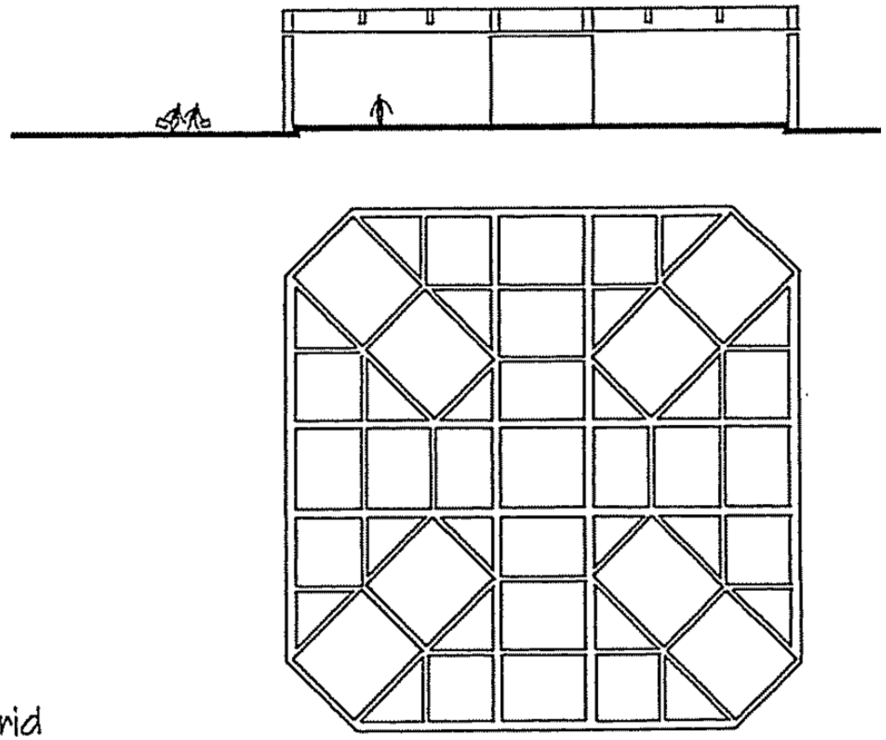
SOLID WEB BEAM GRID SYSTEMS (4/6)

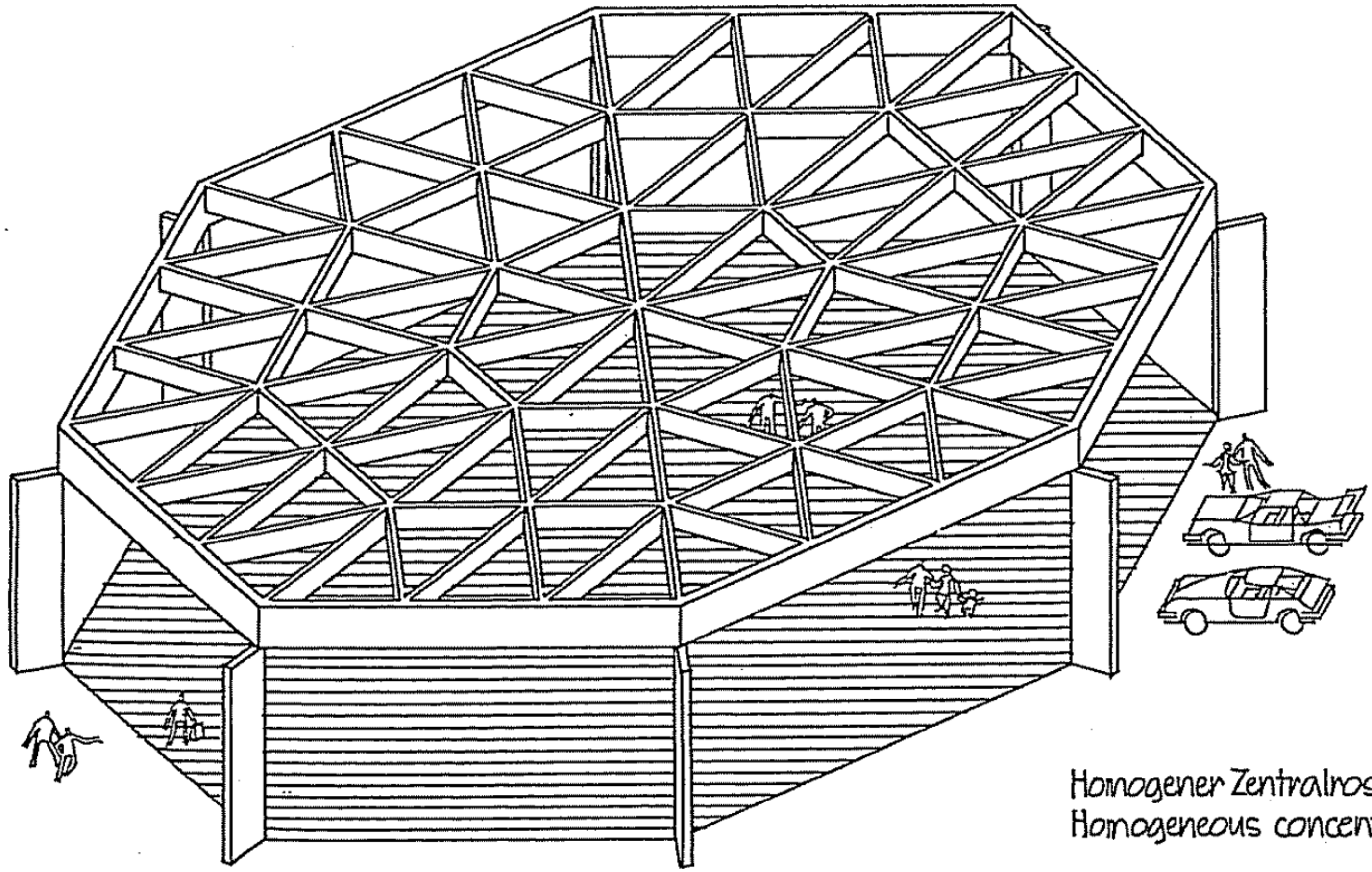


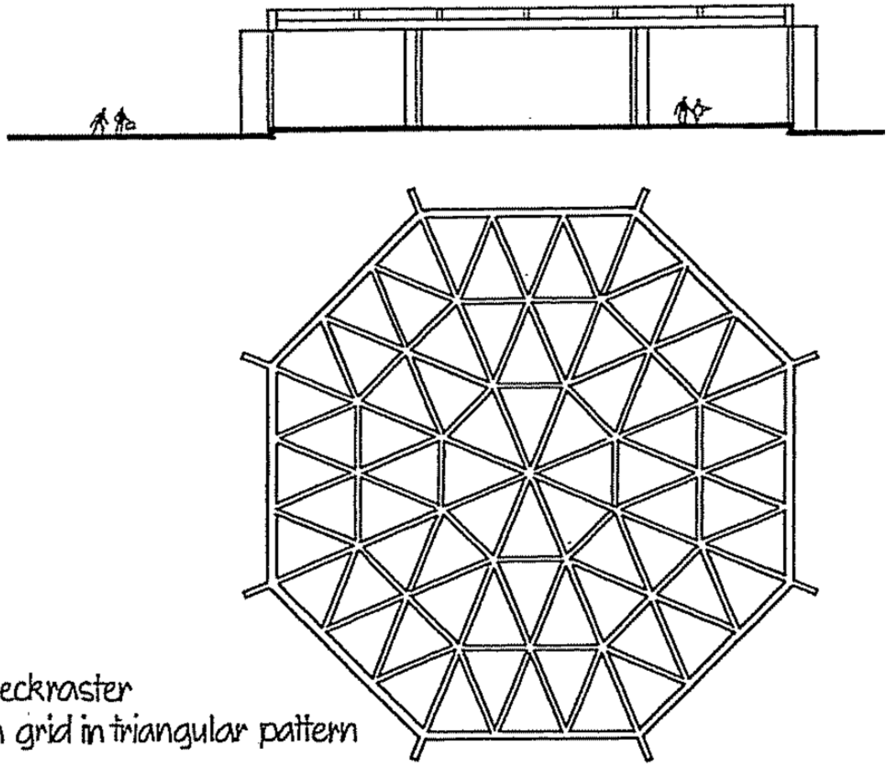
SOLID WEB BEAM GRID SYSTEMS (5/6)



Abgestufter Zentral-Rost
Gradated concentric beam grid

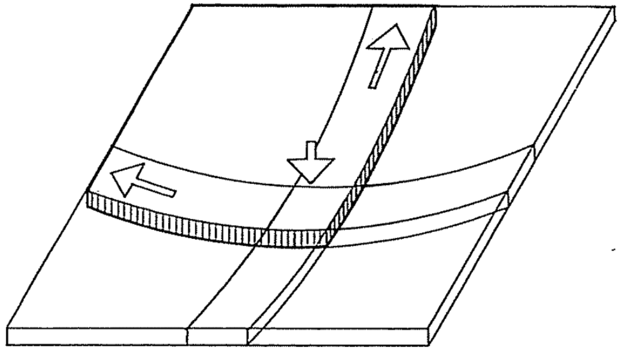






Homogener Zentralrost im Dreieckraster
Homogeneous concentric beam grid in triangular pattern

BEARING MECHANICS OF THE SIMPLY SUPPORTED SLAB (1/2)

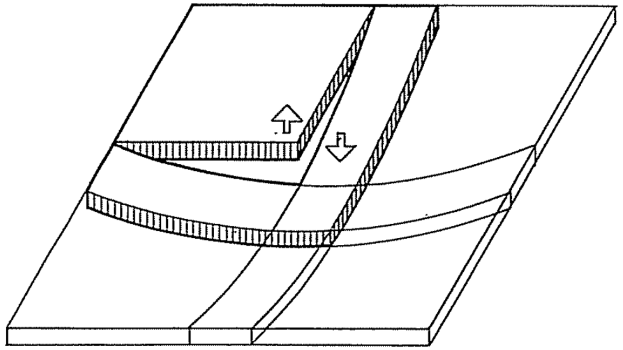


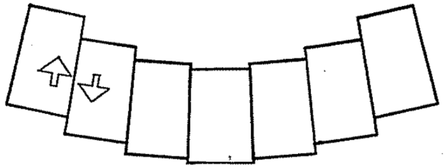
Balken-Wirkung

Durch Biegemechanik (kombinierte Zug-, Druck- und Scherwirkung) werden die Lasten wie beim Balkenträger nach den Auflagern abgetragen

Beam action

Through bending mechanics (combined action of tension, compression and shear) the loads are transmitted to the supports like in a beam



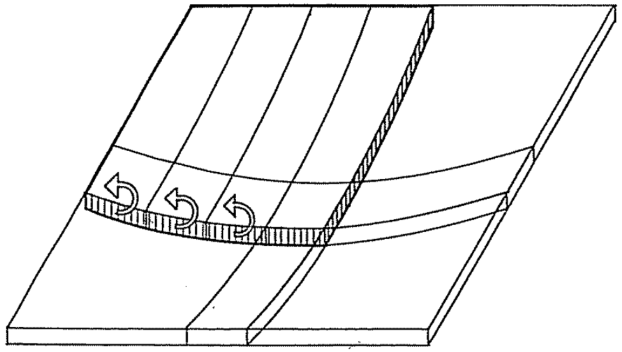


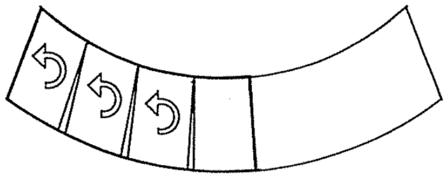
System-Gesamtreaktion

Mittels senkrechter Scherkräfte werden die Lasten vom durchgebogenen Streifen auf die angrenzenden Streifen weitergeleitet. Dadurch wird das Gesamtsystem in die Widerstandsmechanik einbezogen, auch bei Punktbelastung

Total system reaction

Through vertical shear forces the loads are transmitted from the deflected strip to the bordering strips. Thus, the total system is taken into the mechanics of resisting deflections, including those produced by point loading



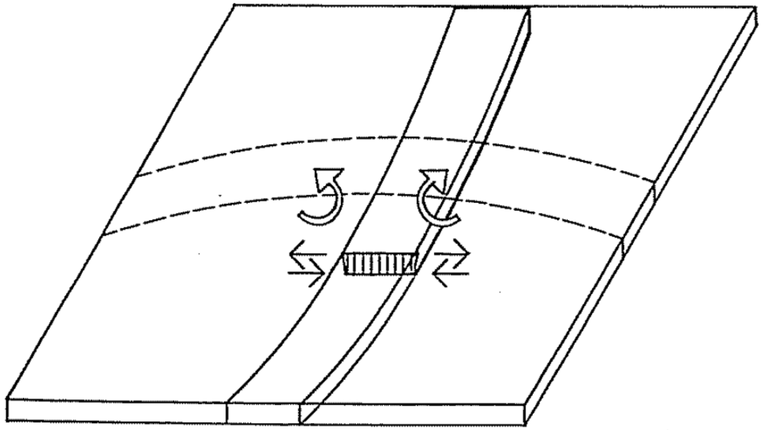


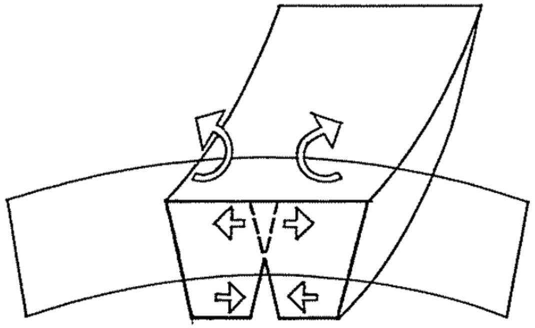
Drillkräfte-Mechanik

Infolge Durchbiegung werden die einzelnen Plattenstreifen quer zur Tragrichtung verdreht: Drillmomente. Durch Drillsteifigkeit können bis zur Hälfte der Lasten auf die Auflager abgetragen werden

Torsional force mechanics

As result of bending deflection the single slab strips are twisted transversely to the spanning direction: Twisting moments. Through stiffness against torsion up to one half of the loads can be transmitted to the supports



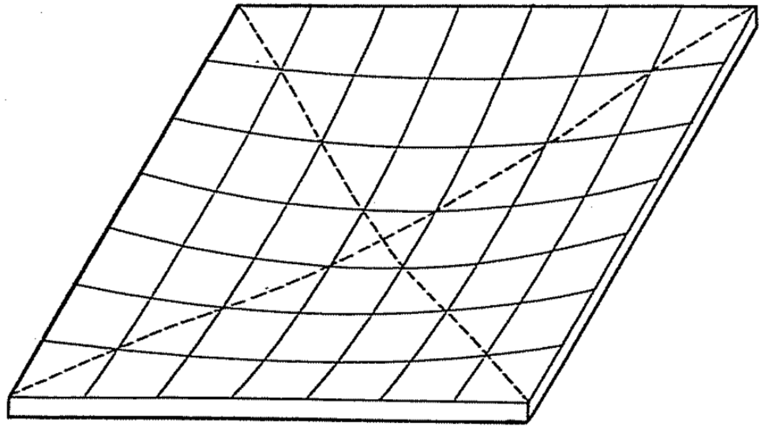


Negative Querbiegung

Wegen der Volumenkonstanz des Materials führt die Durchbiegung des Plattenstreifens im Querschnitt zur Vergrößerung der Druckzone und zur Verkleinerung der Zugzone. Dieser Vorgang löst ein umgekehrtes Drehmoment in der Querachse aus

Negative cross bending

Due to the constancy in volume of material the bending deflection of the slab strip induces enlargement of the compressive zone of section and diminishing of the tensile zone. This action leads to a reverse rotational moment in the transverse axis



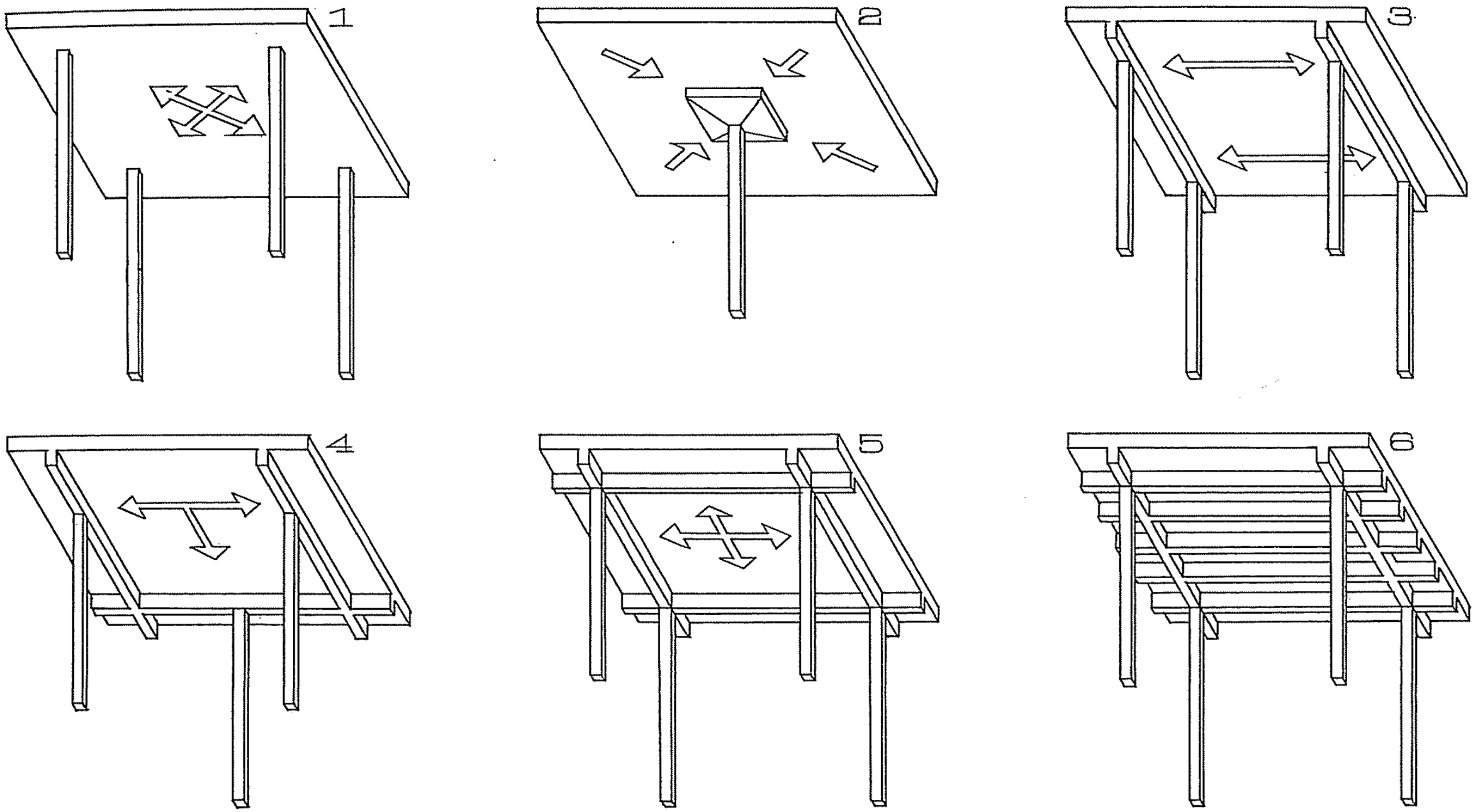
Einspannwirkung in der Diagonalen

Die Eckzonen der Platte weisen infolge zweier rechtwinklig zusammenlaufenden Randunterstützungen erhöhte Steifigkeit auf. Dadurch können sich die Diagonalstreifen der Platte mit den Enden nicht frei über den Auflagern drehen. Sie verhalten sich wie eingespannte Träger mit umgekehrter Durchbiegung an den Enden und mit größerem Tragvermögen

Fixed-end action in the diagonals

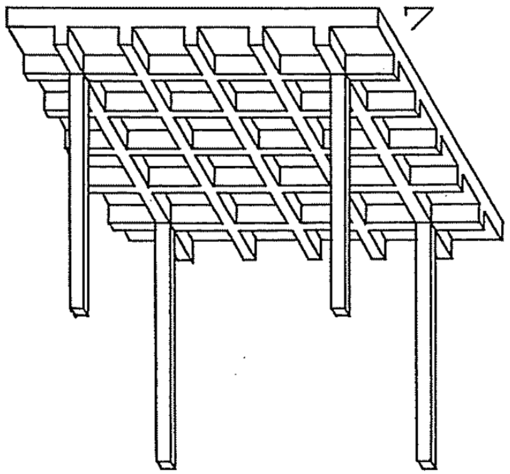
Because at the corners two edge supports meet at right angles, the corner areas show increased stiffness. Therefore the diagonal strips of the slab cannot rotate freely with their ends above the supports. They act much like fixed-end beams with reversed bending deflection and hence with increased bearing capacity

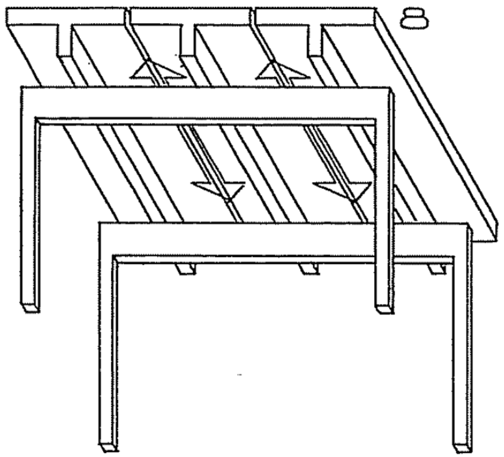
STRUCTURAL SLAB SYSTEMS: LOAD TRANSFER AND OPTIMIZATION FORMS (1/2)

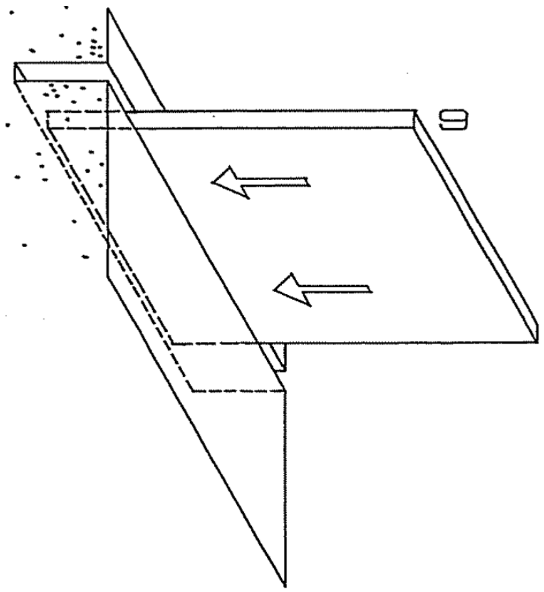


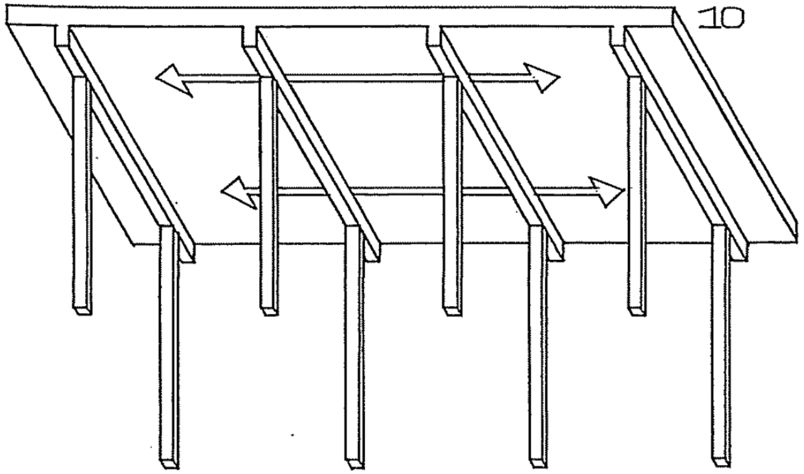
1 Flat, two-way spanning slab / beamless floor
2 Point-supported slab / mushroom floor slab with drop panel
3 Slab simply supported along two opposite sides / one-way slab
4 Slab supported along three sides
5 Simply supported slab / two-way (reinforced) slab
6 Ribbed slab / ribbed floor

STRUCTURAL SLAB SYSTEMS: LOAD TRANSFER AND OPTIMIZATION FORMS (2/2)



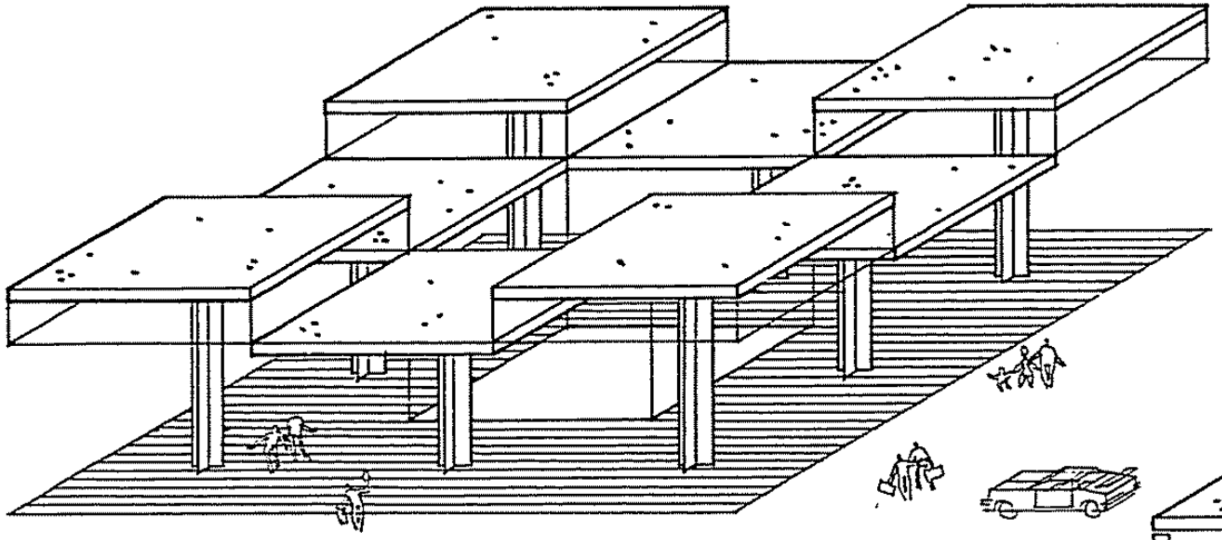




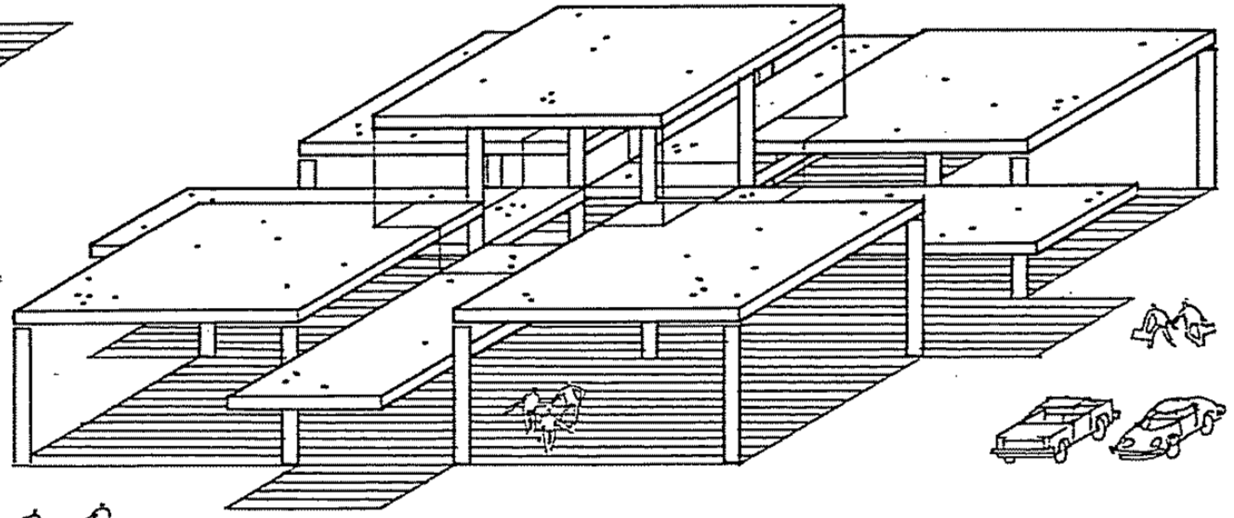


1	Ebene, kreuzweise gespannte Platte / unterzuglose Decke	Flat, two-way spanning slab / beamless floor
2	Punktförmig gelagerte Platte / Pilzdecke (mit Auflagerverstärkung)	Point-supported slab / mushroom floor slab with drop panel
3	Zweiseitig gelagerte Platte / einachsig gespannte (bzw. bewehrte) Decke	Slab simply supported along two opposite sides / one-way slab
4	Dreiseitig gelagerte Platte	Slab supported along three sides
5	Vierseitig gelagerte Platte / kreuzweise gespannte (bewehrte) Decke	Simply supported slab / two-way (reinforced) slab
6	Rippendecke / Rippenplatte	Ribbed slab / ribbed floor
7	Kassettendecke	Waffle slab / coffered slab
8	Plattenbalken	T-beam floor
9	Kragplatte / eingespannte Platte	Cantilevered slab / fixed-end slab
10	Mehrfeldplatte	Multi-span slab

EXAMPLE OF STRUCTURAL SLAB SYSTEMS (1/3)

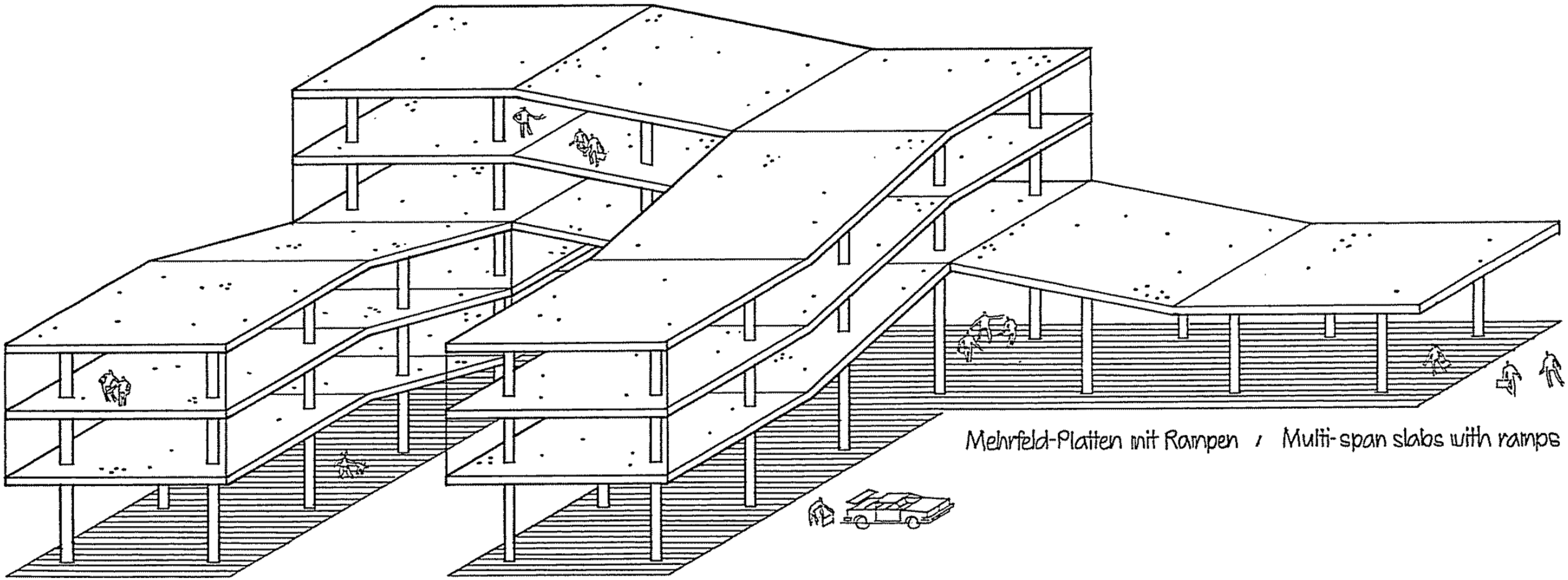


Einzelplatten mit Zentralstütze / Single slabs with central column

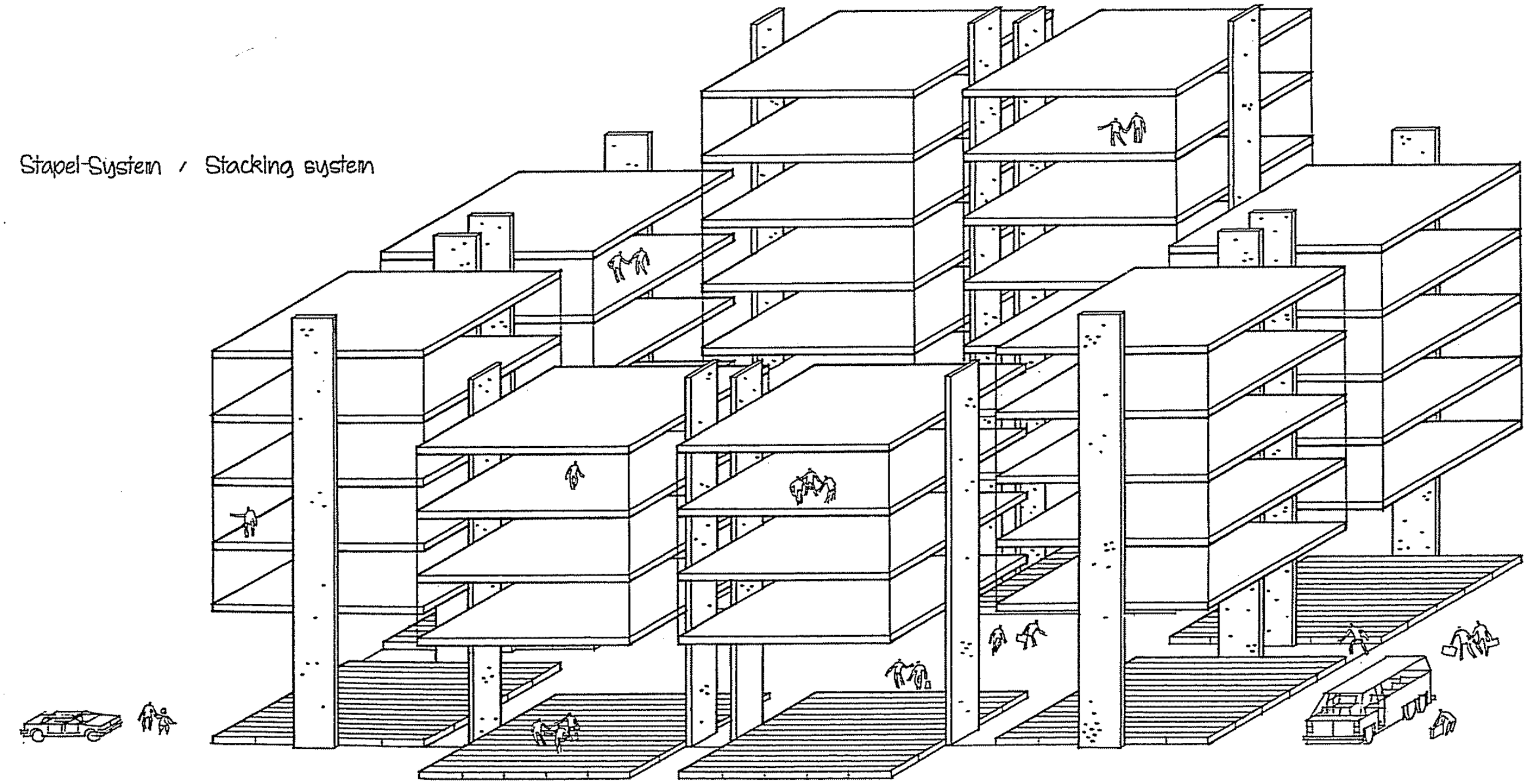


Einfeldplatten mit Eckstützen / Single-bay slabs with corner columns

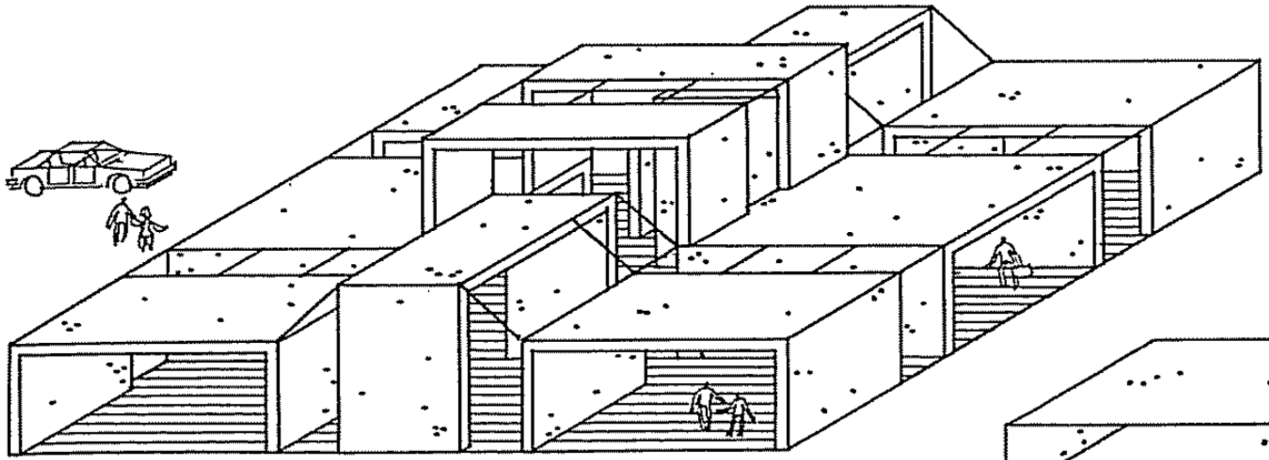
EXAMPLE OF STRUCTURAL SLAB SYSTEMS (2/3)



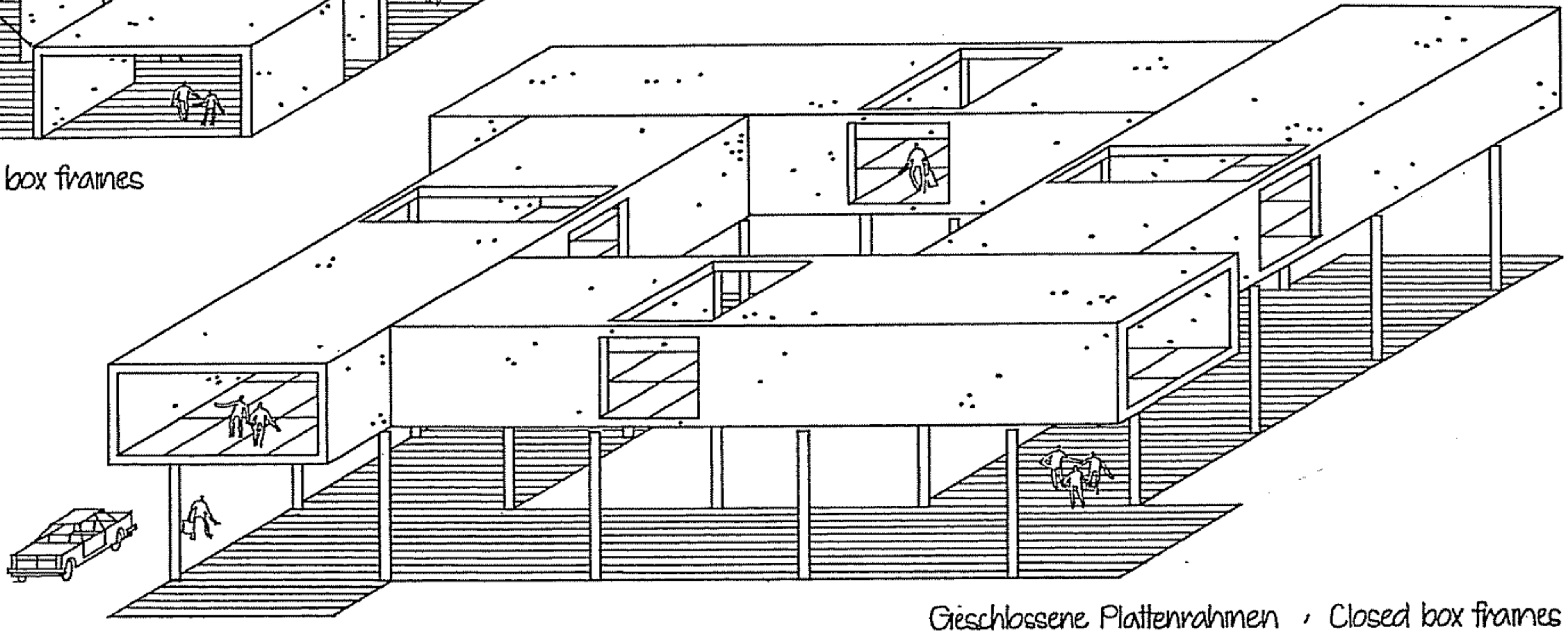
EXAMPLE OF STRUCTURAL SLAB SYSTEMS (3/3)



EXAMPLE OF BOX FRAME SYSTEMS (1/3)

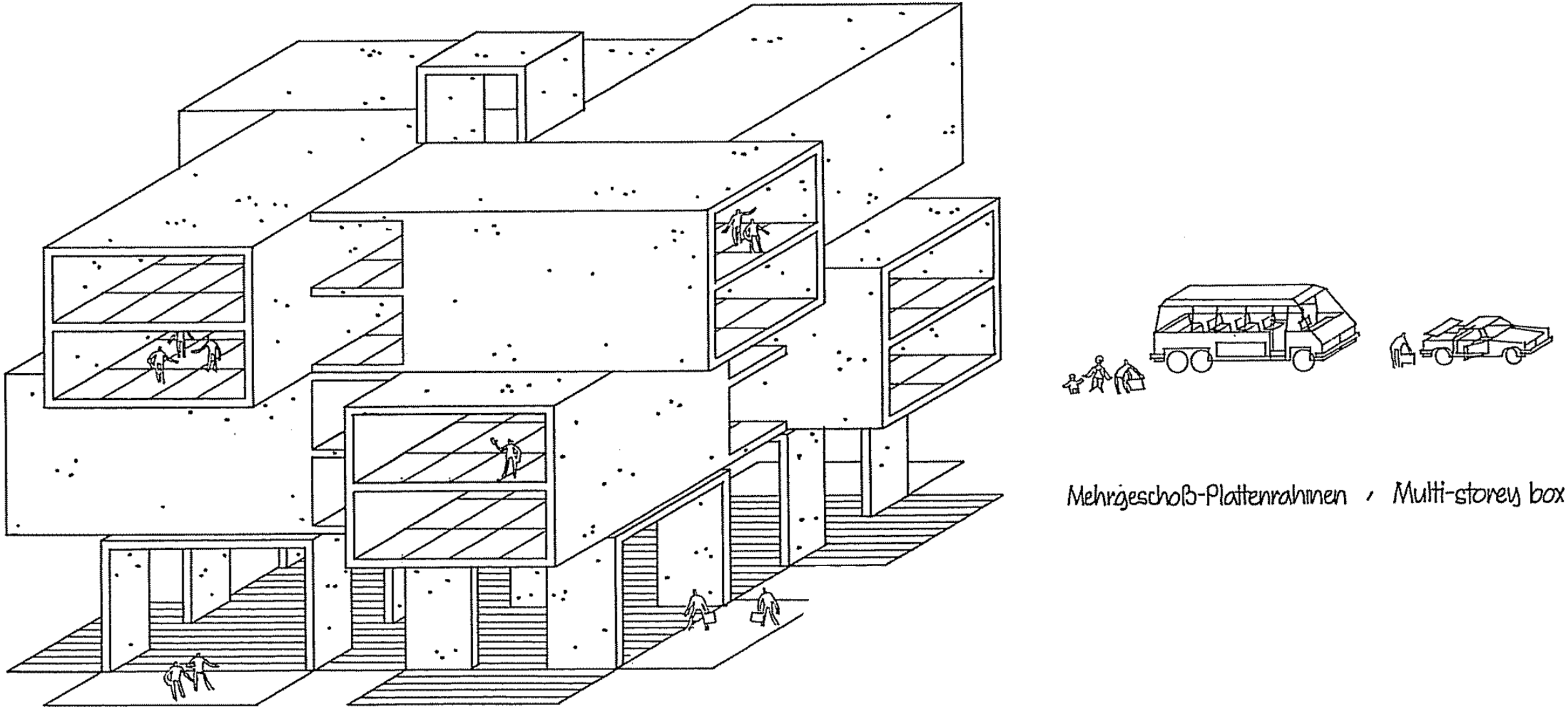


Offene Plattenrahmen , Open box frames



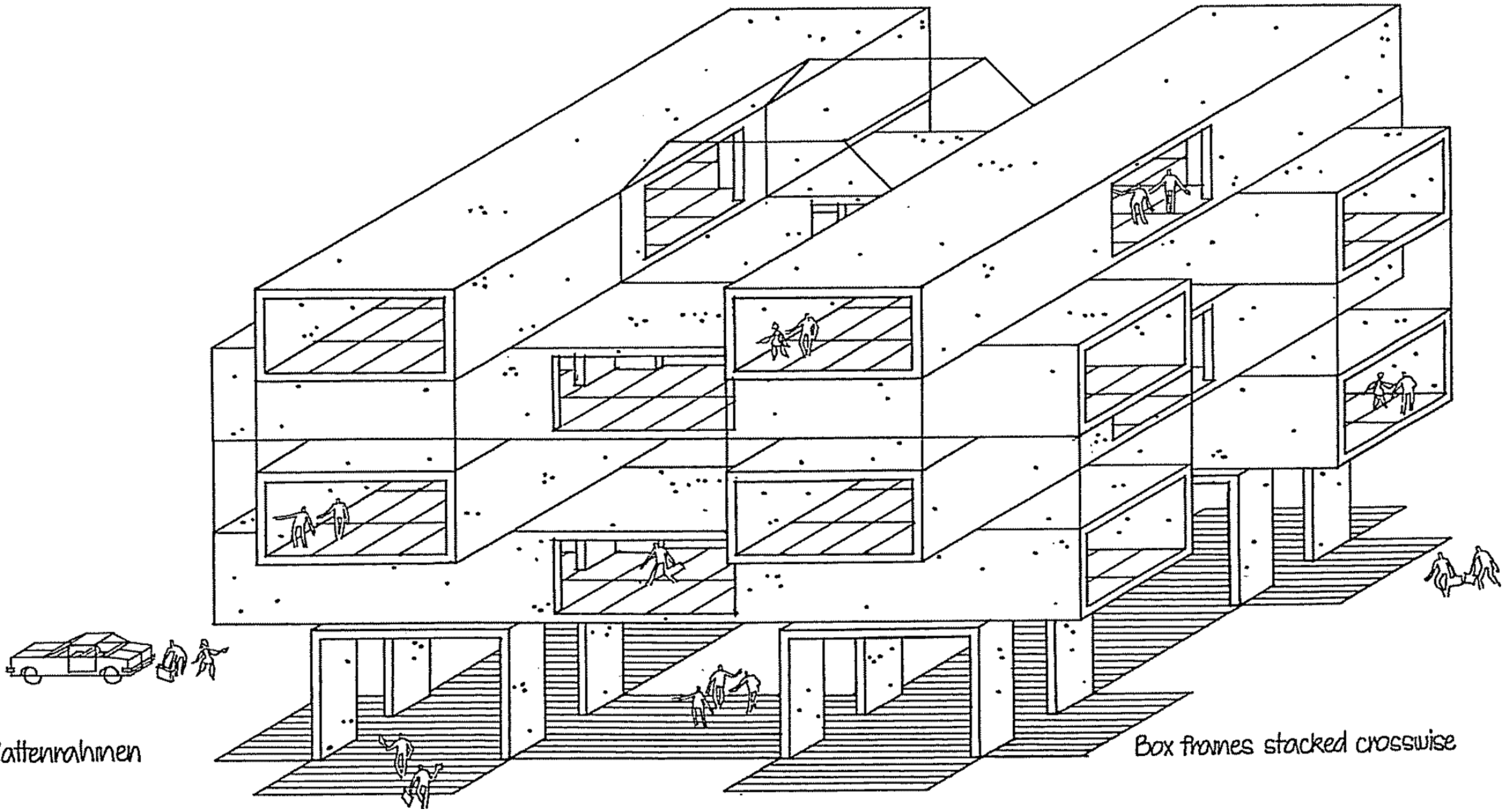
Geschlossene Plattenrahmen , Closed box frames

EXAMPLE OF BOX FRAME SYSTEMS (2/3)



Mehrgeschoß-Plattenrahmen / Multi-storey box frames

EXAMPLE OF BOX FRAME SYSTEMS (3/3)



Kreuzweise gestapelte Plattenrahmen

Box frames stacked crosswise