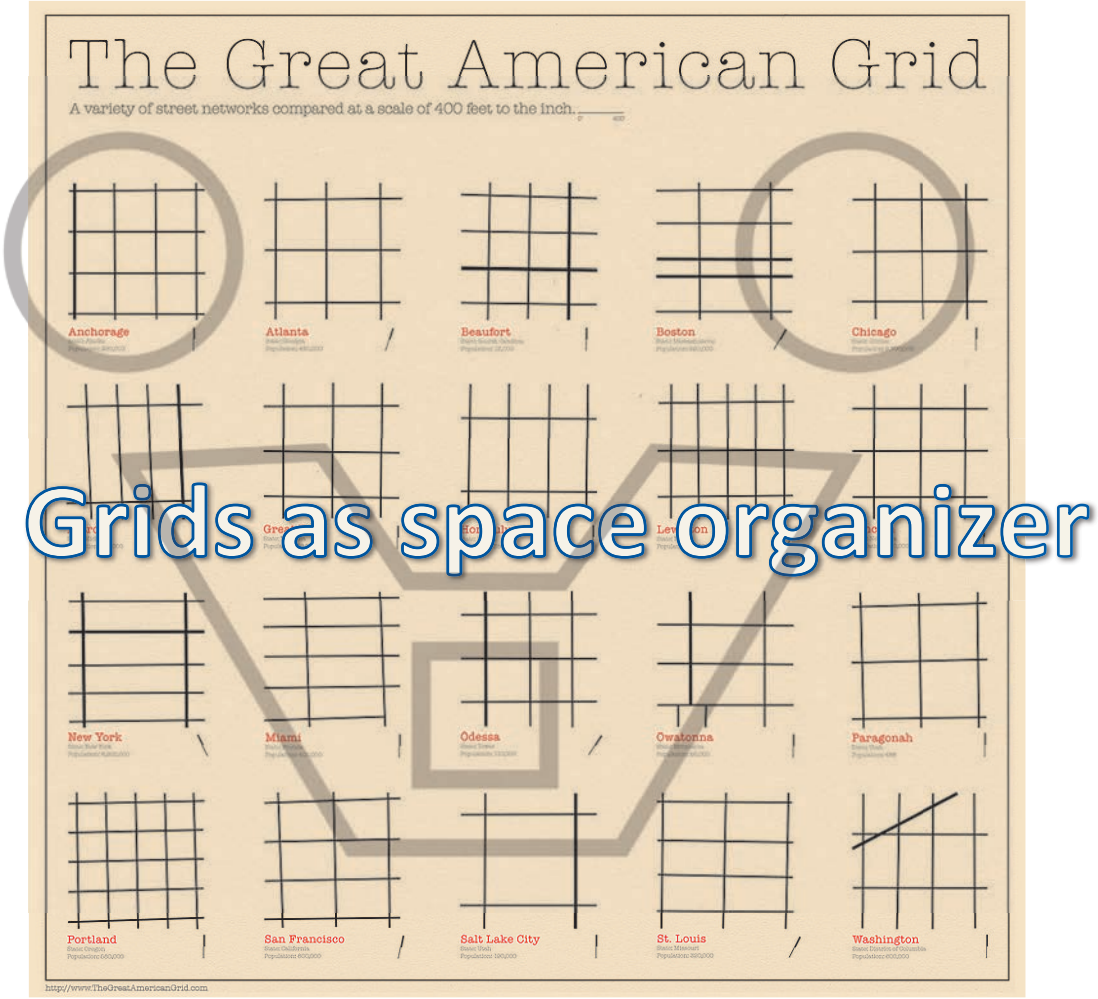
The grammar of building structure and architectural language

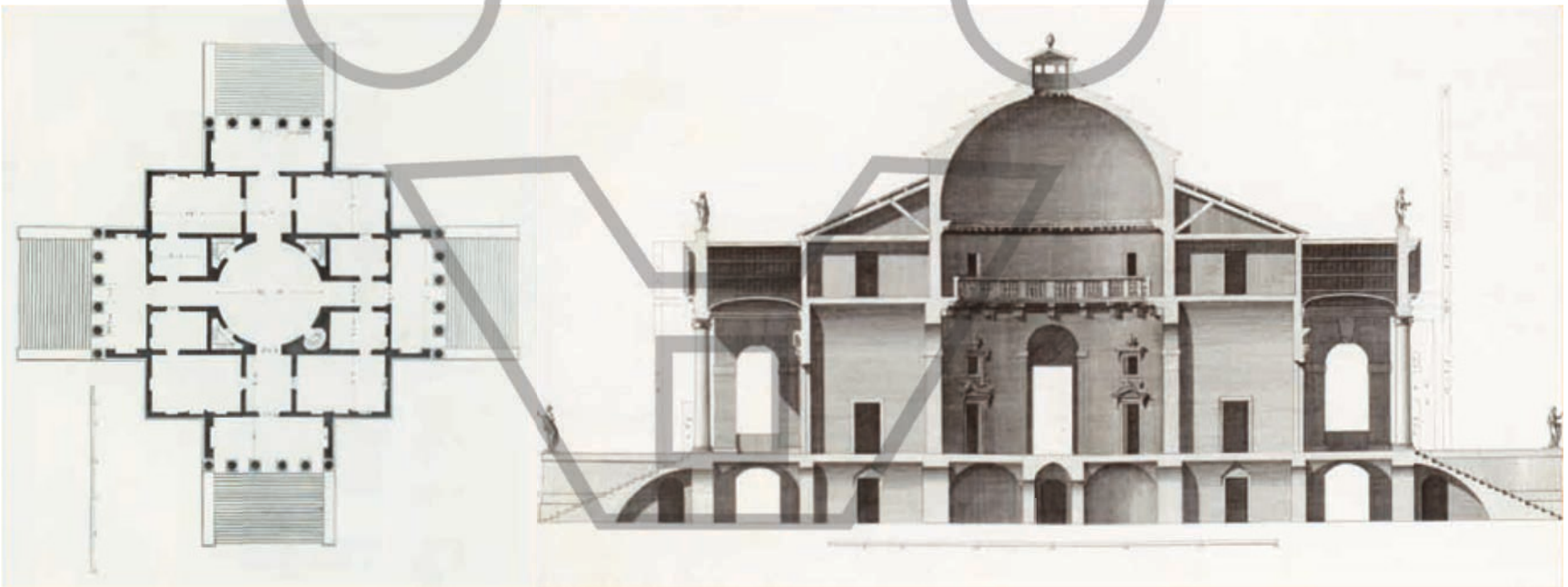
understanding the interrelation between structural components and grids regarding architectural form



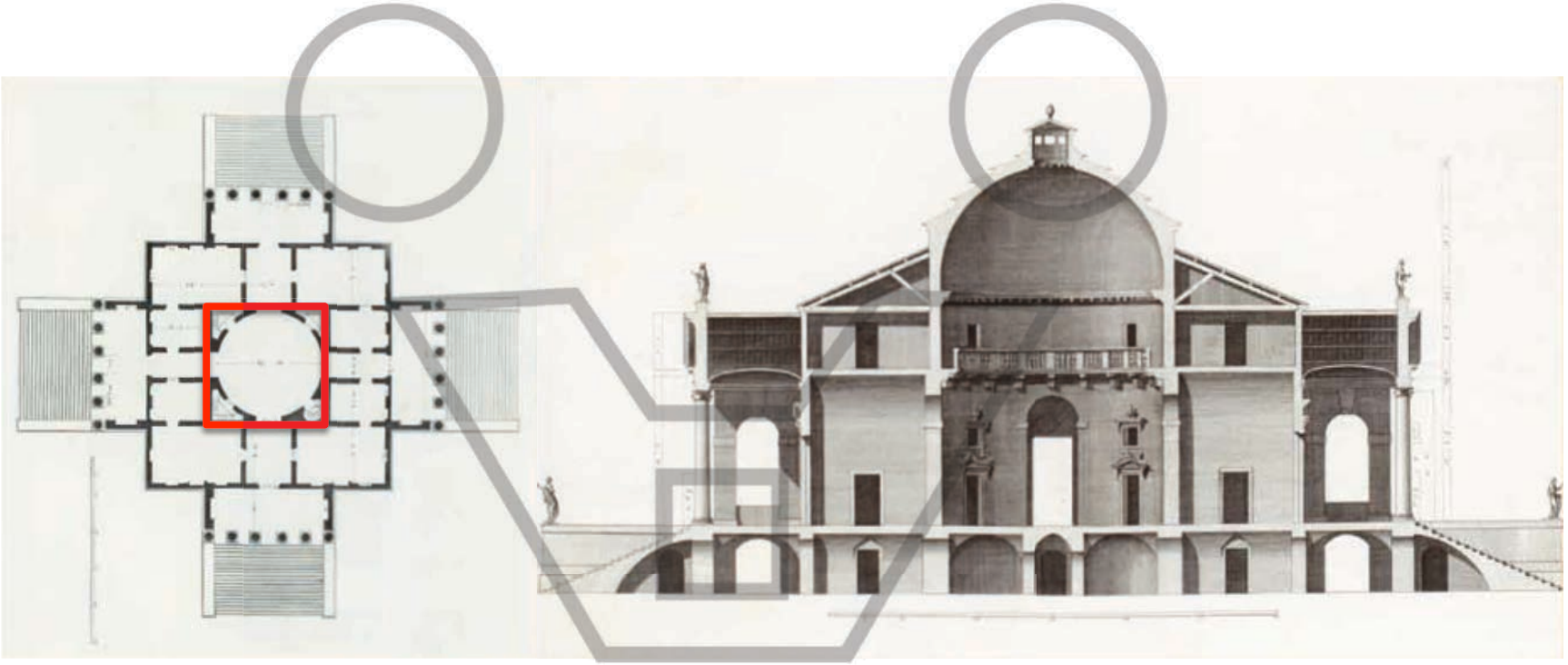
Grids as space organizer

Park Hill is a council housing estate in Sheffield, England.
Designed by Jack Lynn and Ivor Smith and built between 1957 and 1961

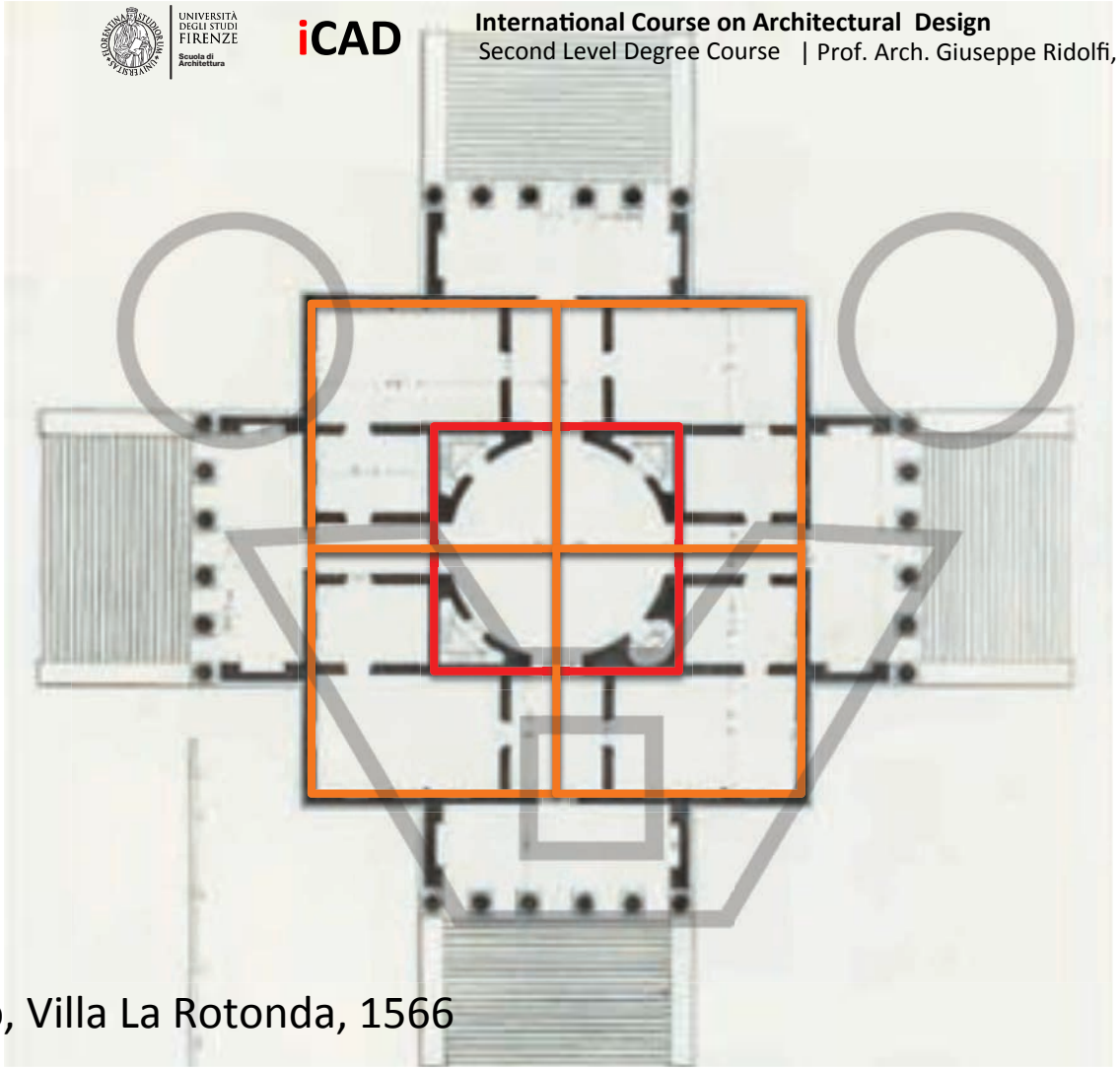
Grids, Modules and Rithms



Andrea Palladio, Villa La Rotonda, 1566



Andrea Palladio, Villa La Rotonda, 1566

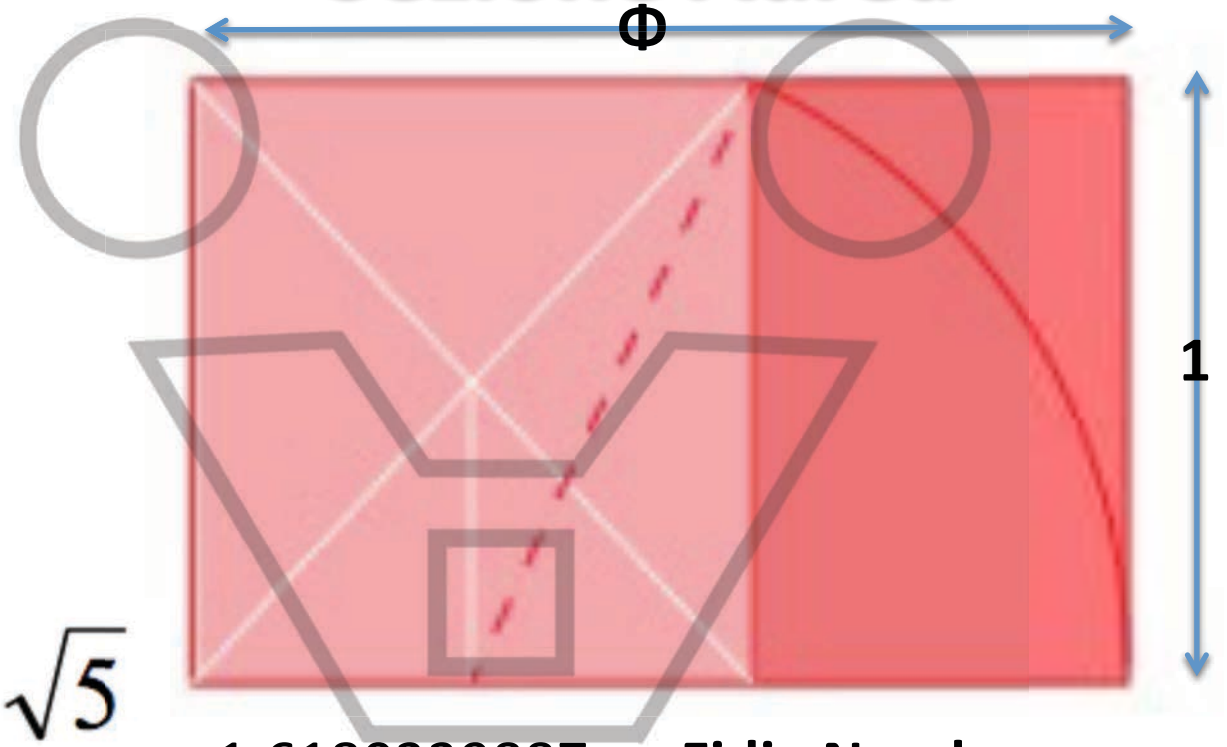


Andrea Palladio, Villa La Rotonda, 1566

Divina Proportione

Andrea Palladio, Villa Emo, 1554

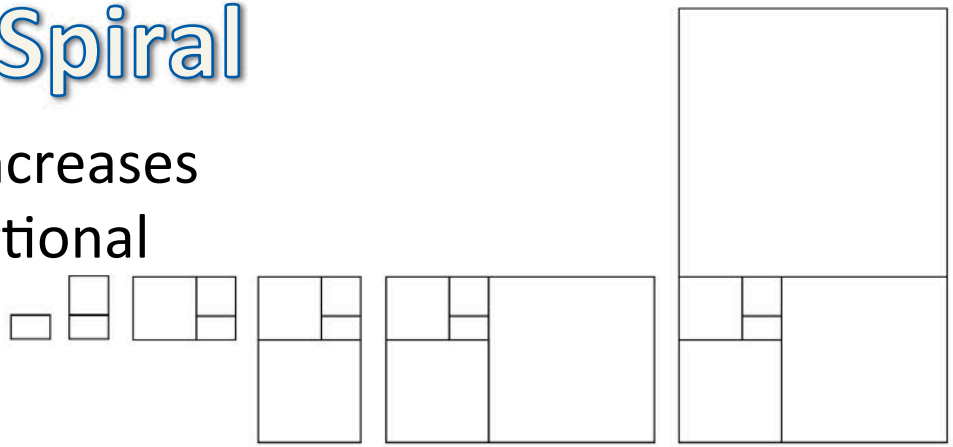
Sezione Aurea



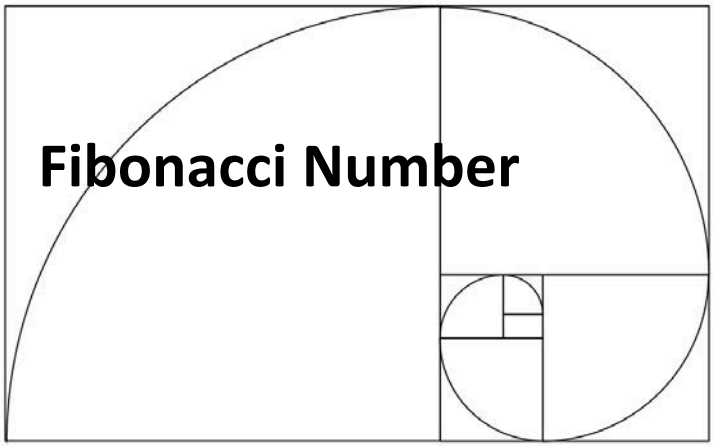
$$\Phi = \frac{1+\sqrt{5}}{2} = 1{,}6180339887\ldots$$ **Fidia Number**

The Golden Spiral

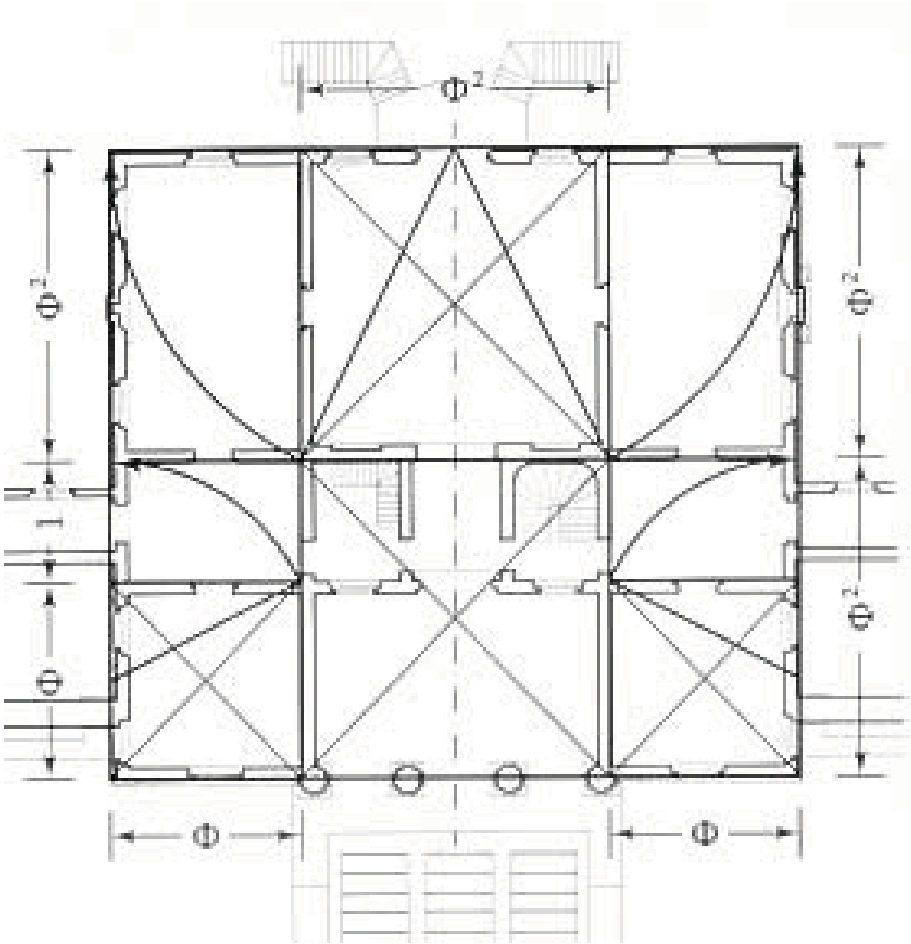
Where circle radius increases with a costant proportional value equal to **1/Φ**

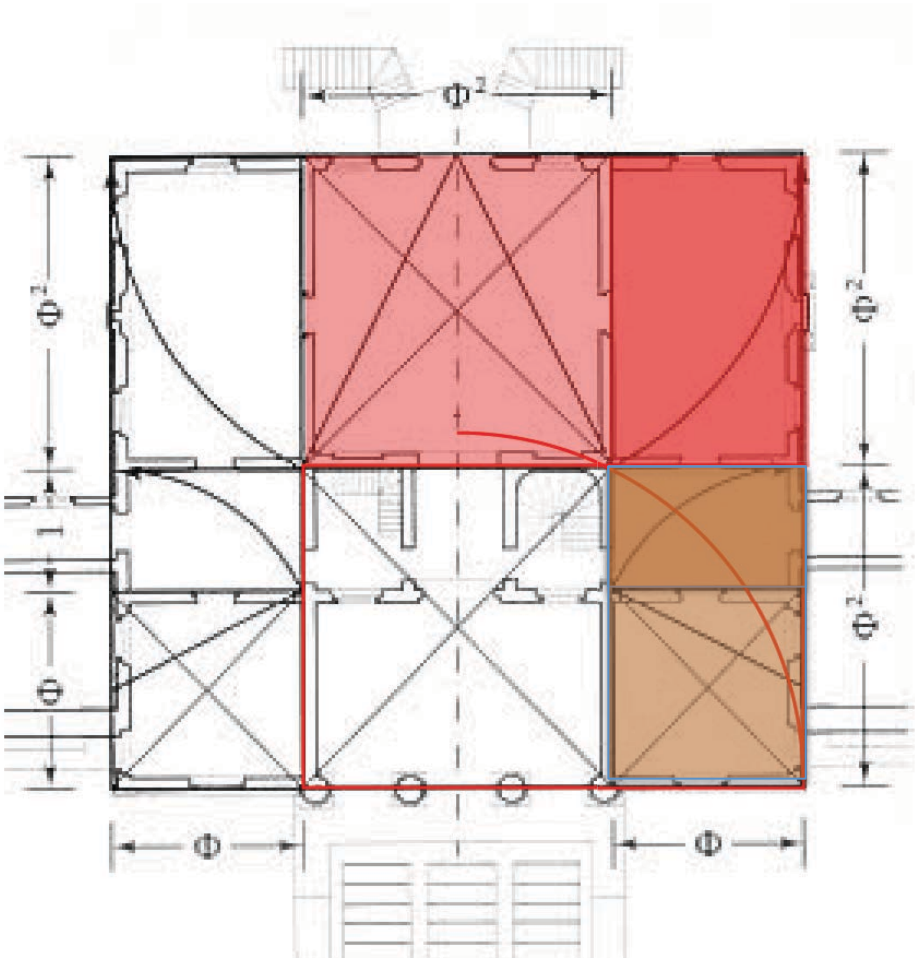


$$\frac{1}{\Phi} = 0{,}6180339887\ldots$$



1
1*Φ
(1*Φ)*Φ
((1*Φ)*Φ)*Φ
.....


Φ
Φ
Φ²
Φ²
1
Φ²
Φ²
Φ


Φ²
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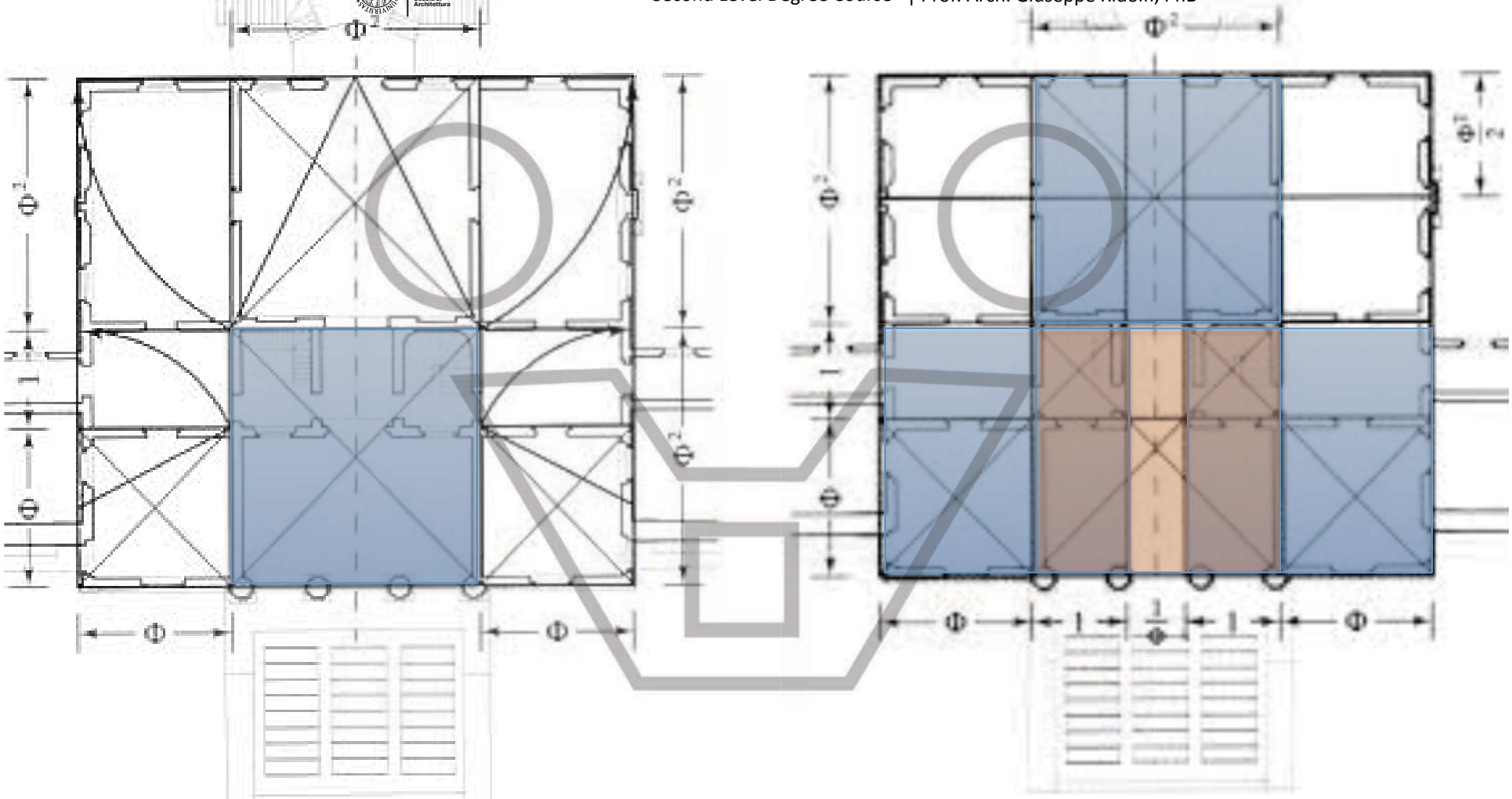

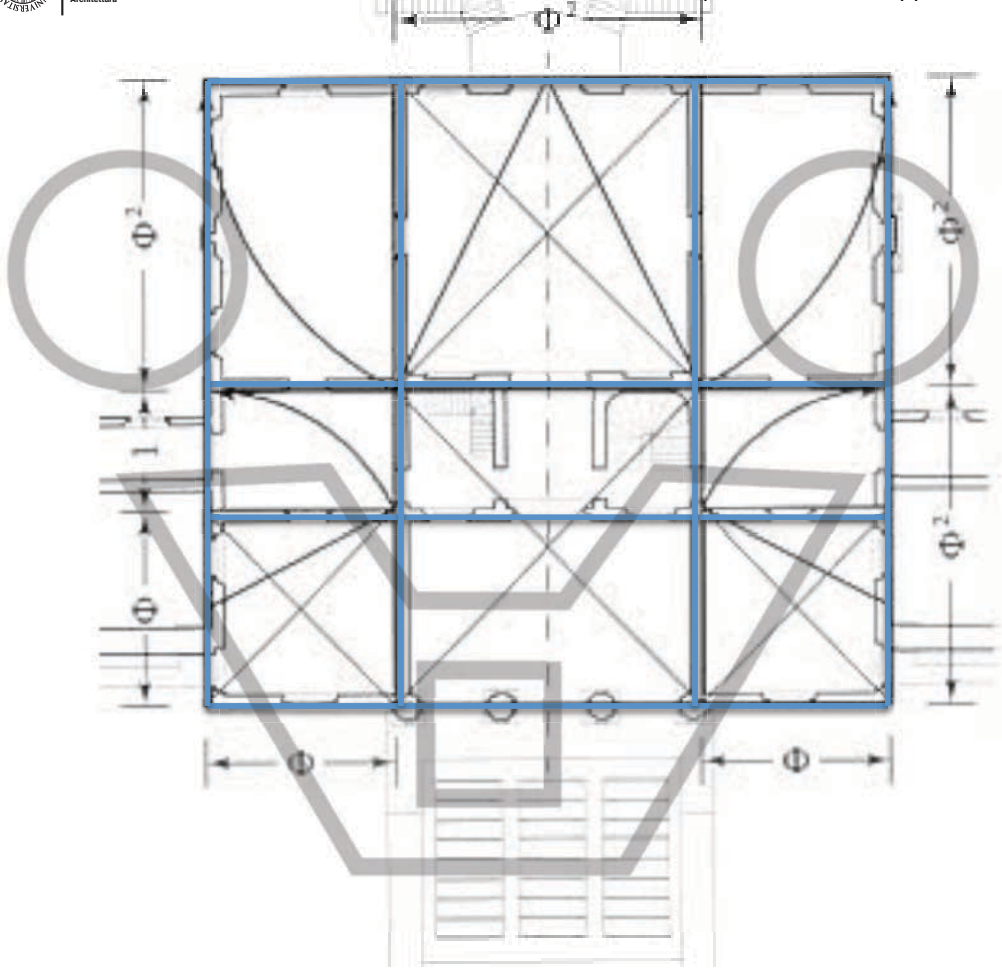

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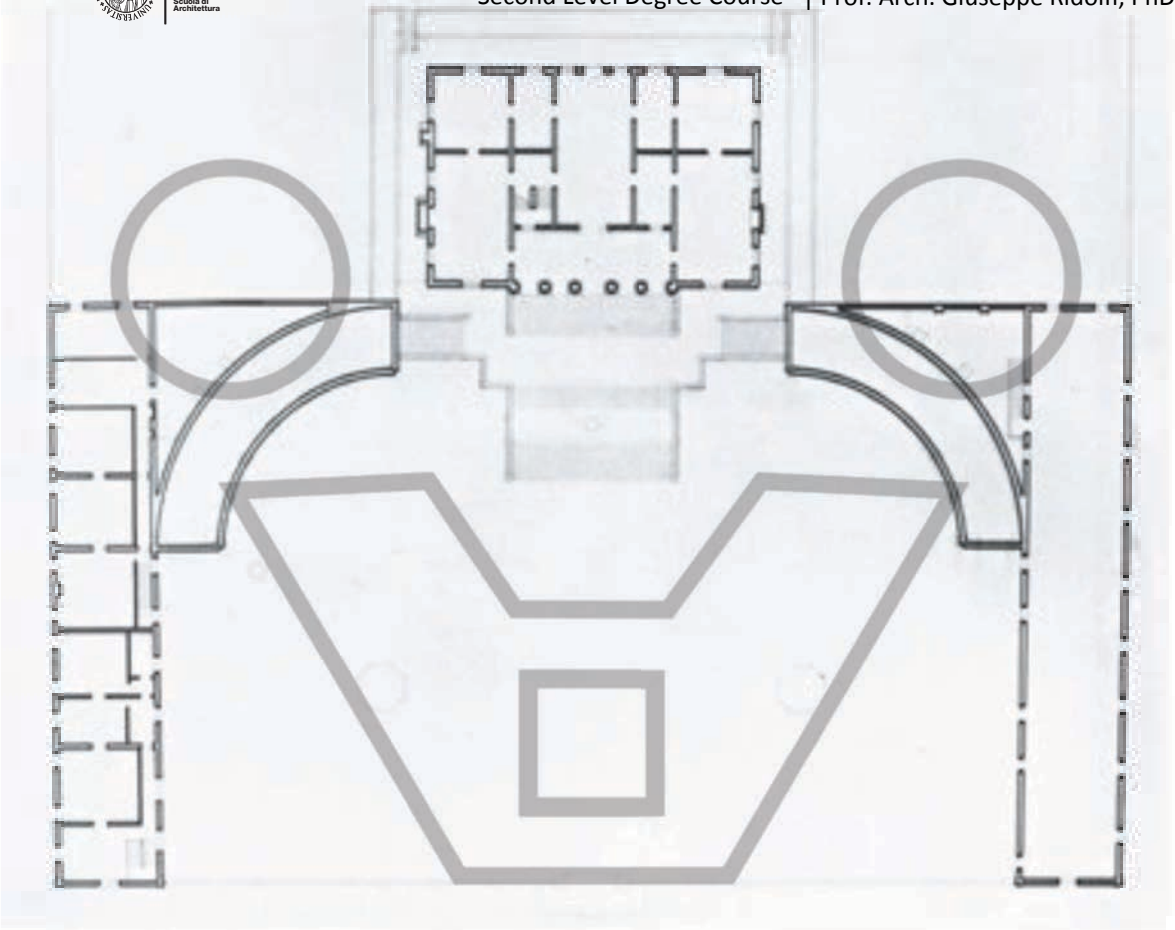
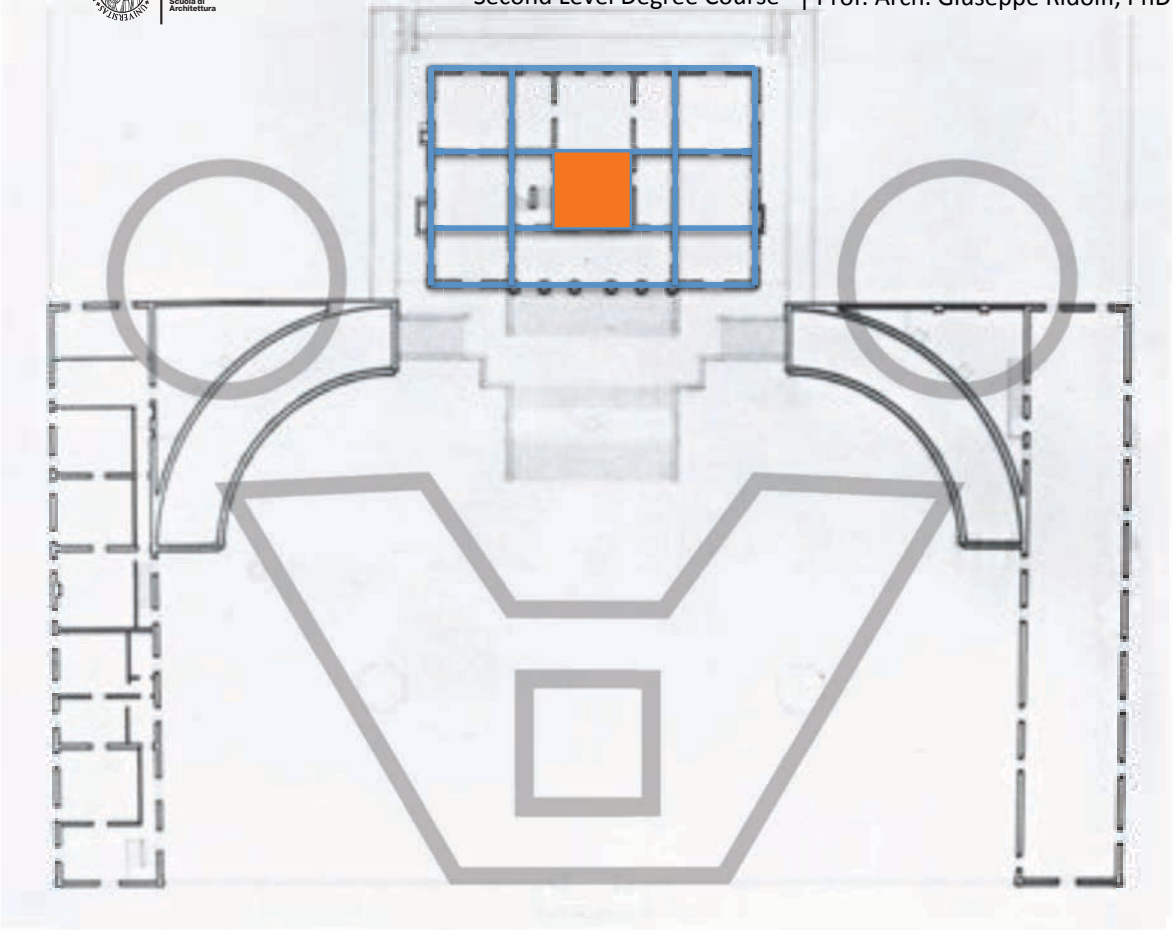


Villa Badoer Planimetria del piano nobile (A. e E. Pereswet Soltan, 1967).



Villa Badoer Planimetria del piano nobile (A. e E. Pereswet Soltan, 1967).

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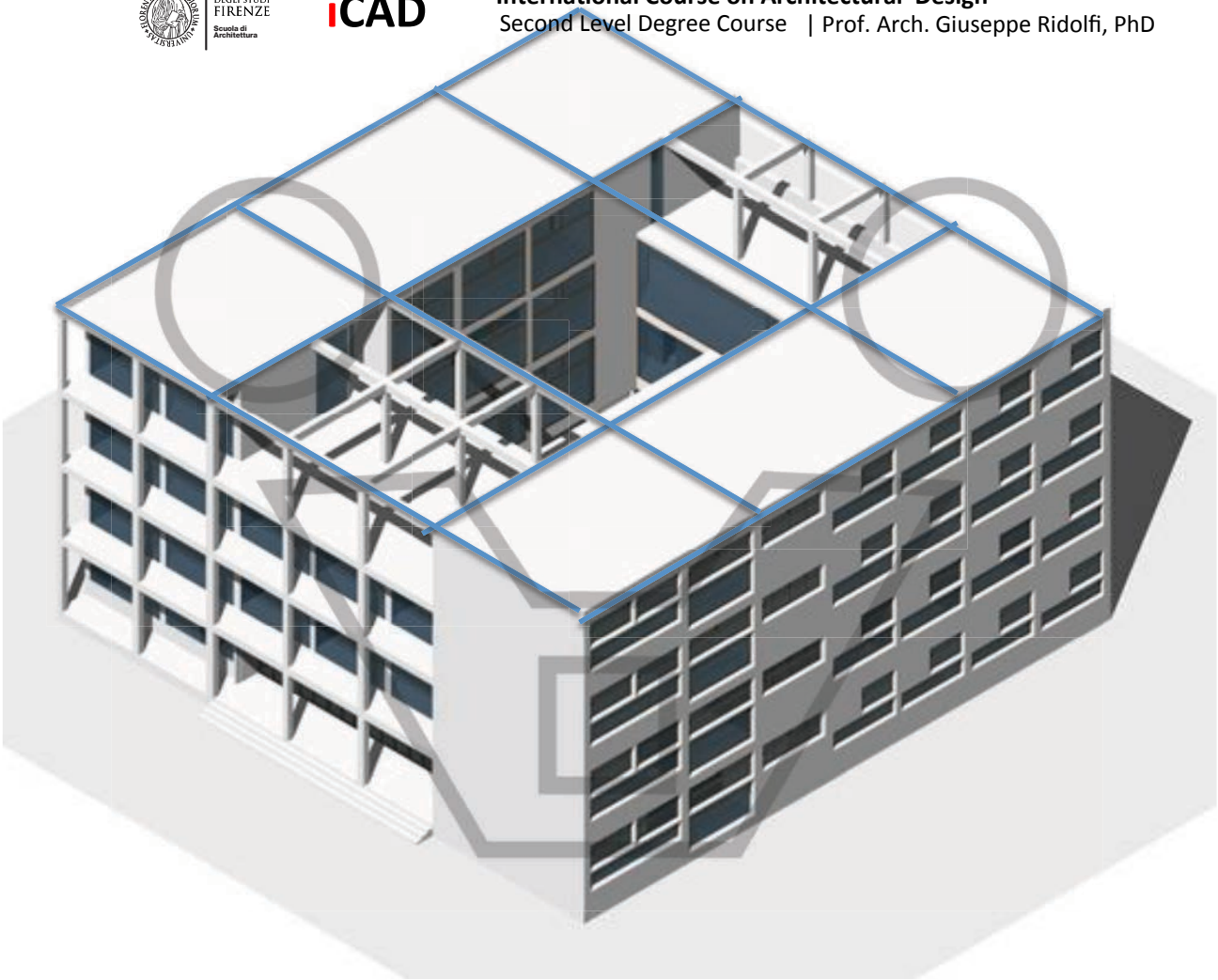
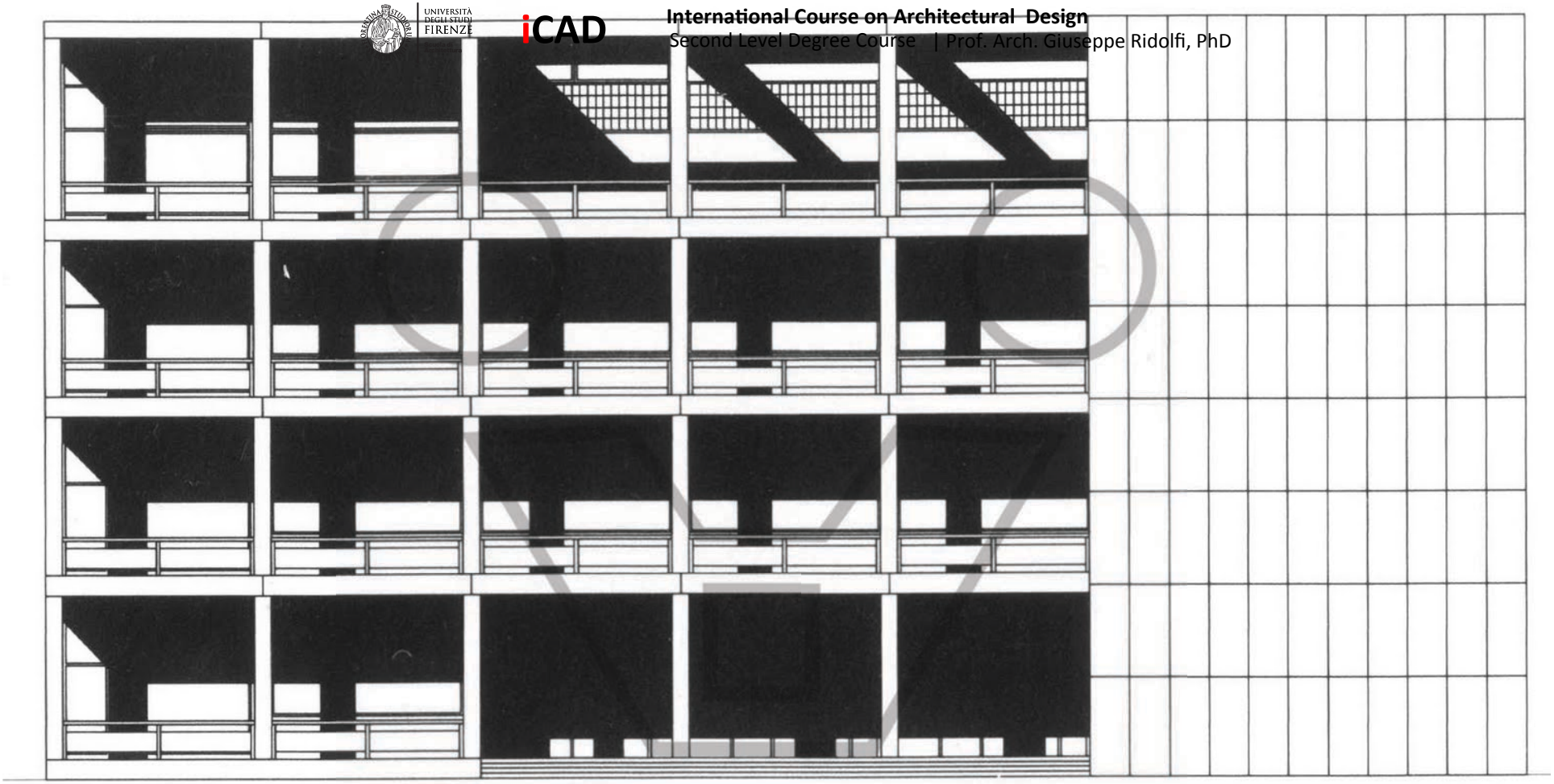
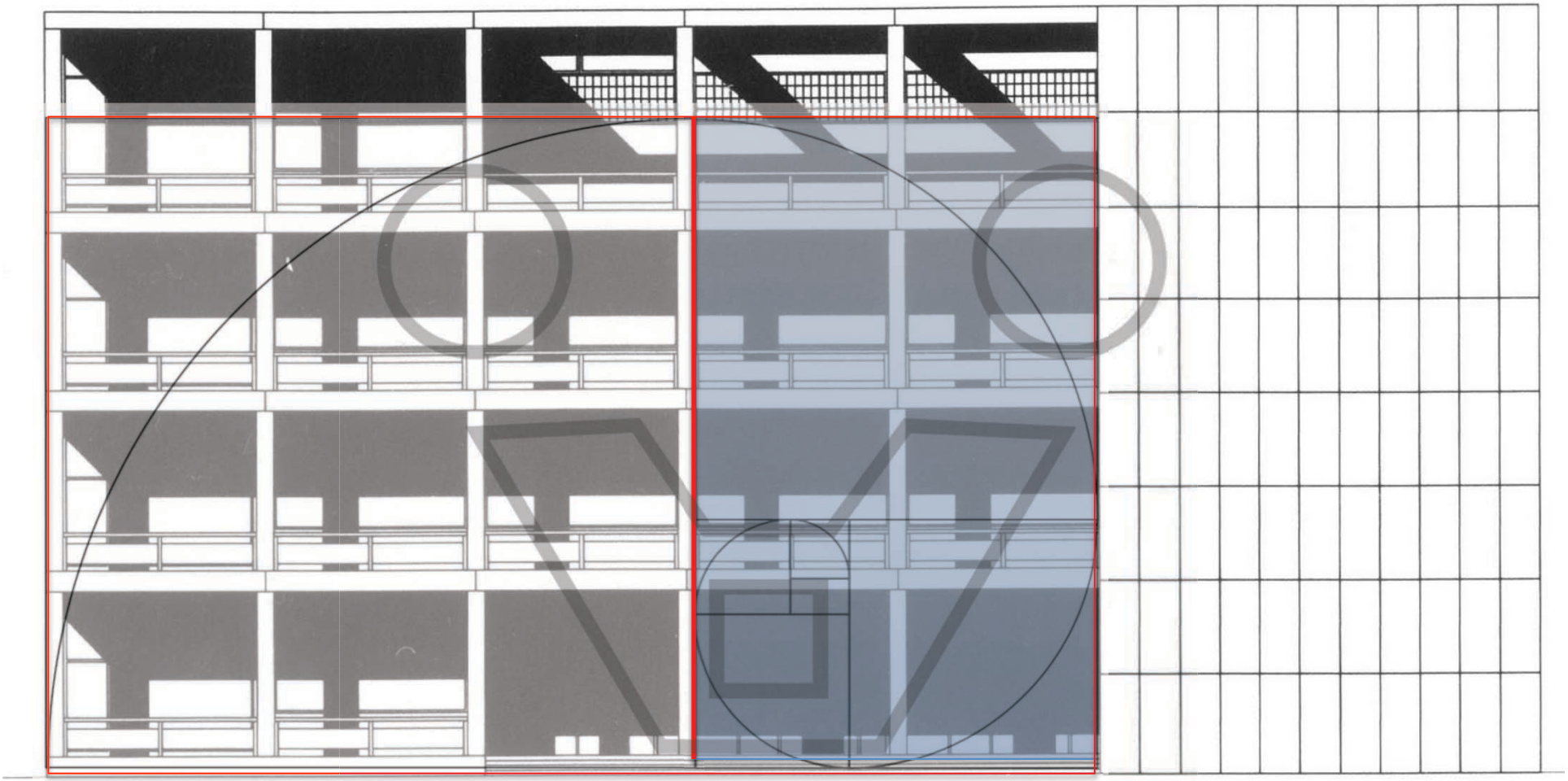
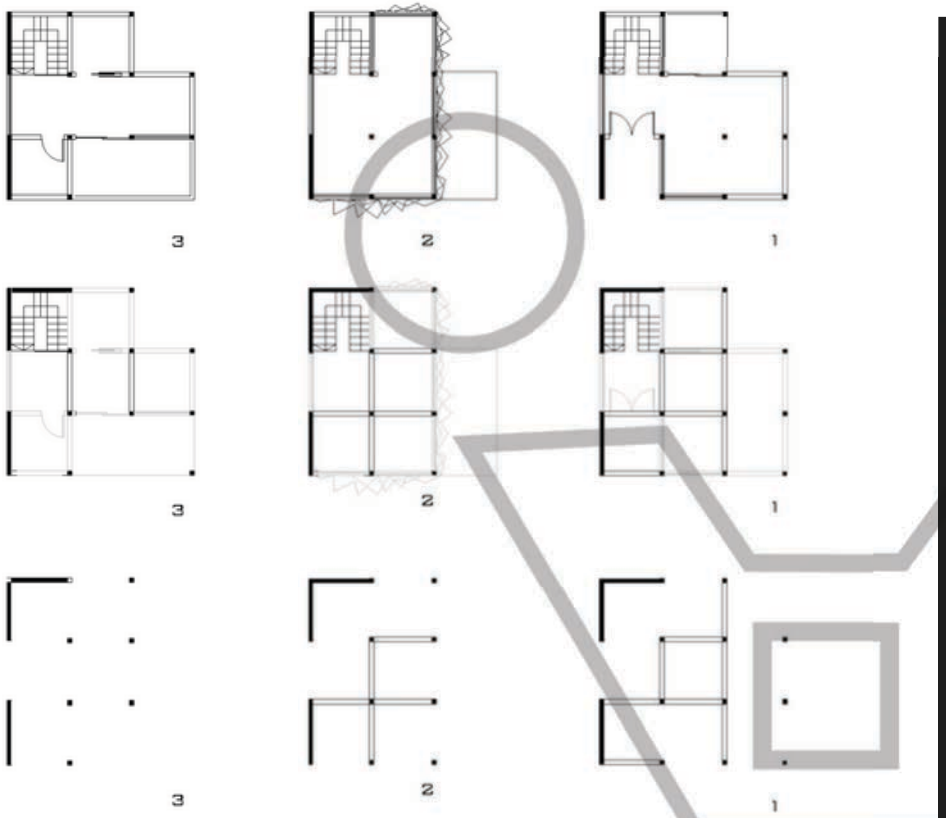
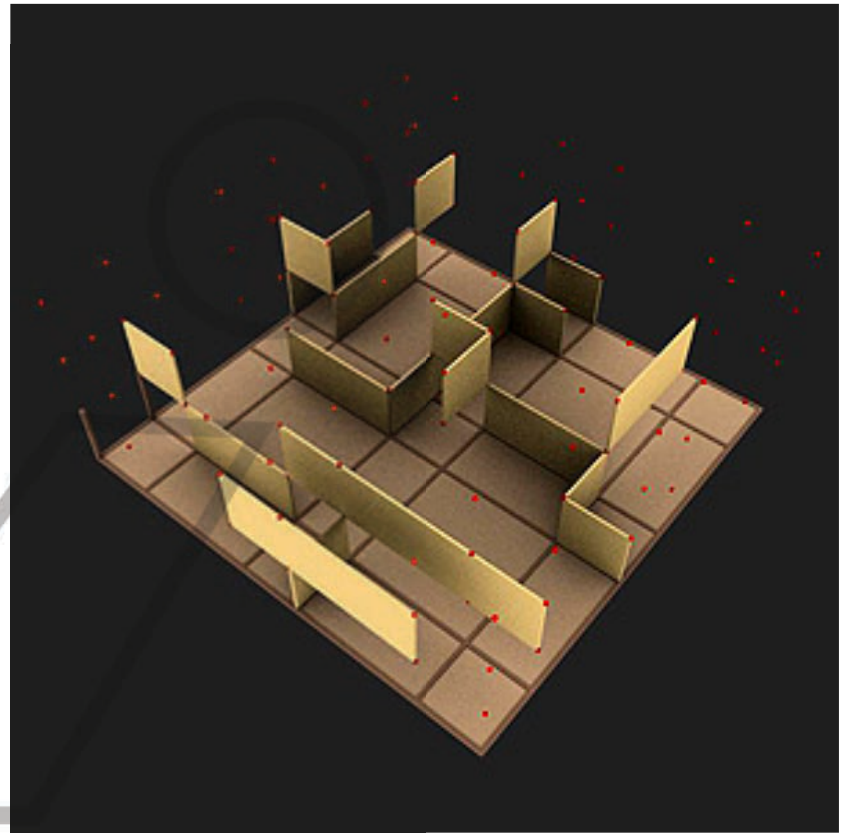




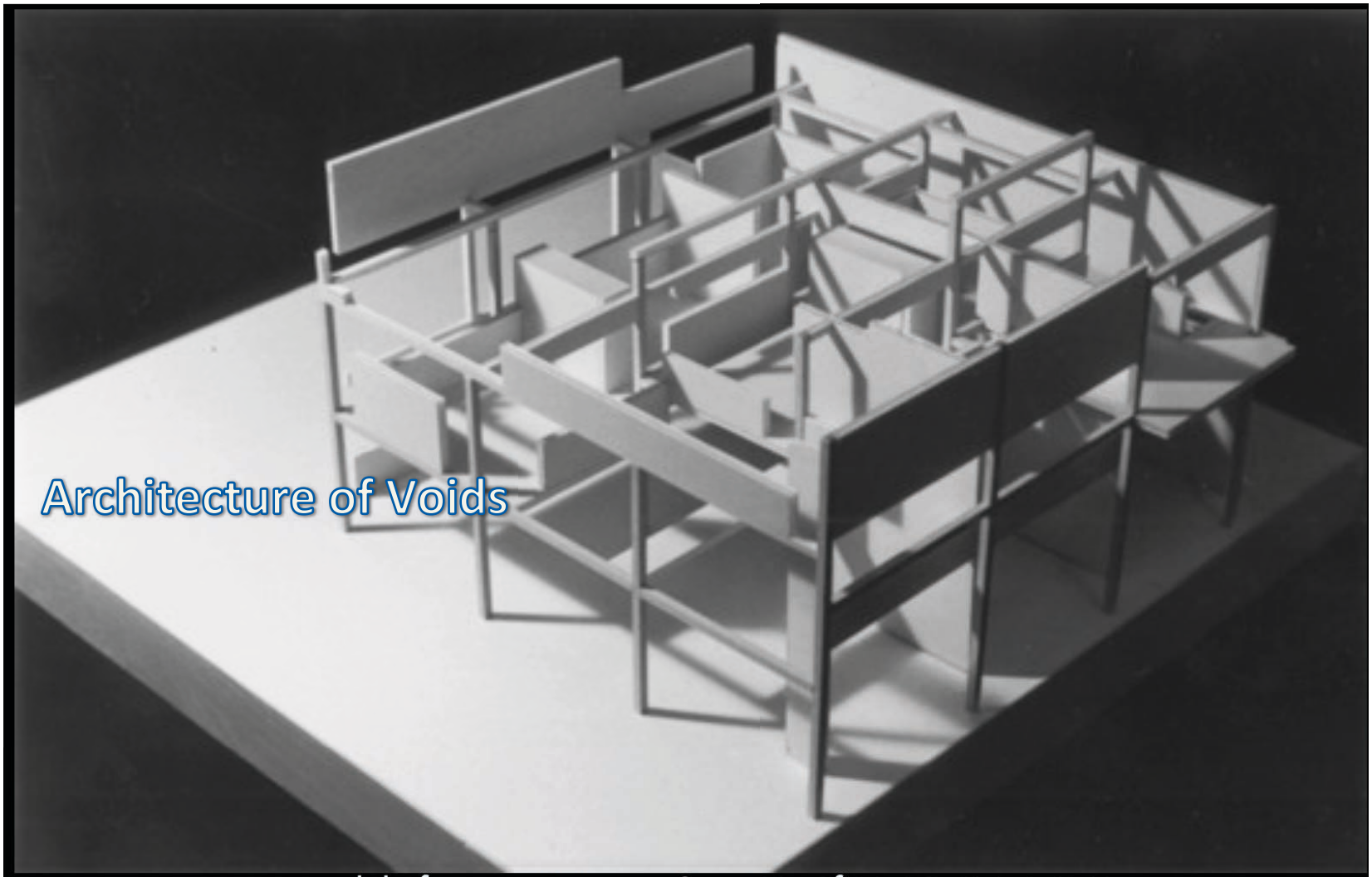
1932-36, Terragni, Como, Casa del Fascio



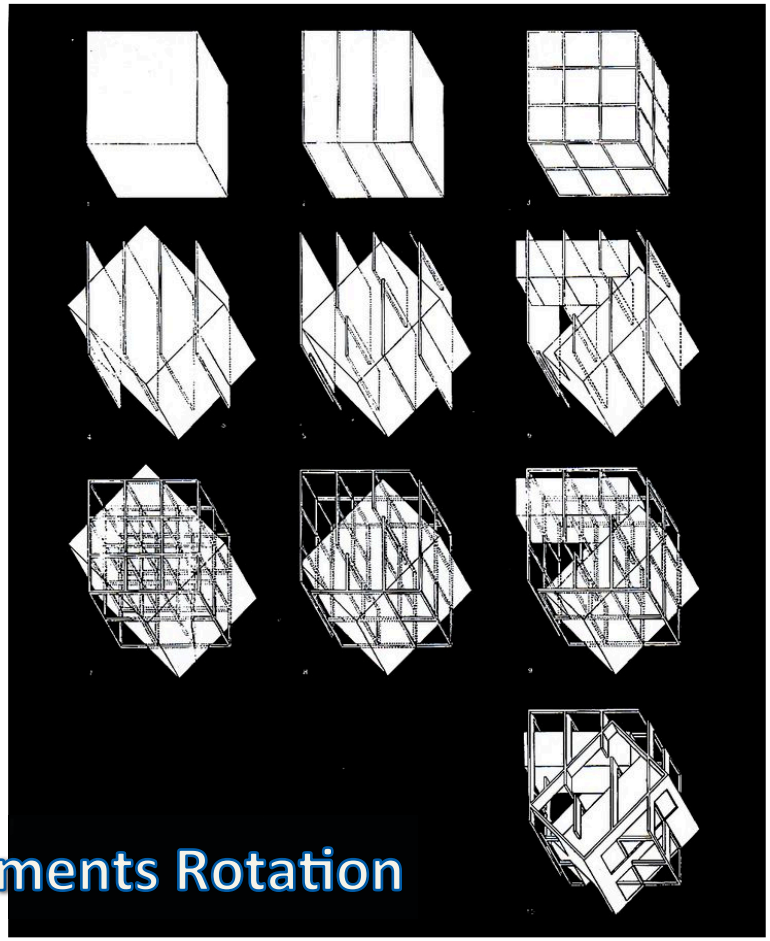




NINE-SQUARE GRID.
Robert Slutzky, John Hejduk, Colin Rowe and Lee Hirsche



A model of House II. Image Courtesy of an-onymous.com



Horizontal Elements Rotation

Eisenman NINE SQUARE GRIDS Research

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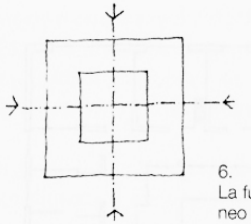
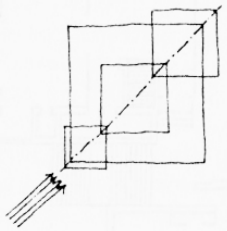
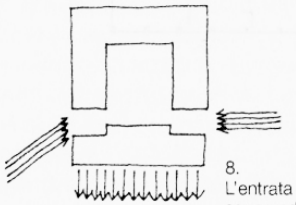
Shifting Elements



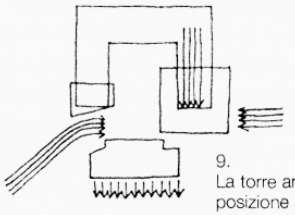
6.
La funzione interna suggerisce un solido rettilineo dal quale è stato estratto il centro.



7.
In risposta alle condizioni esterne si possono ipotizzare due proiezioni angolari.



8.
L'entrata sui due angoli taglia un lato, separando la biblioteca.

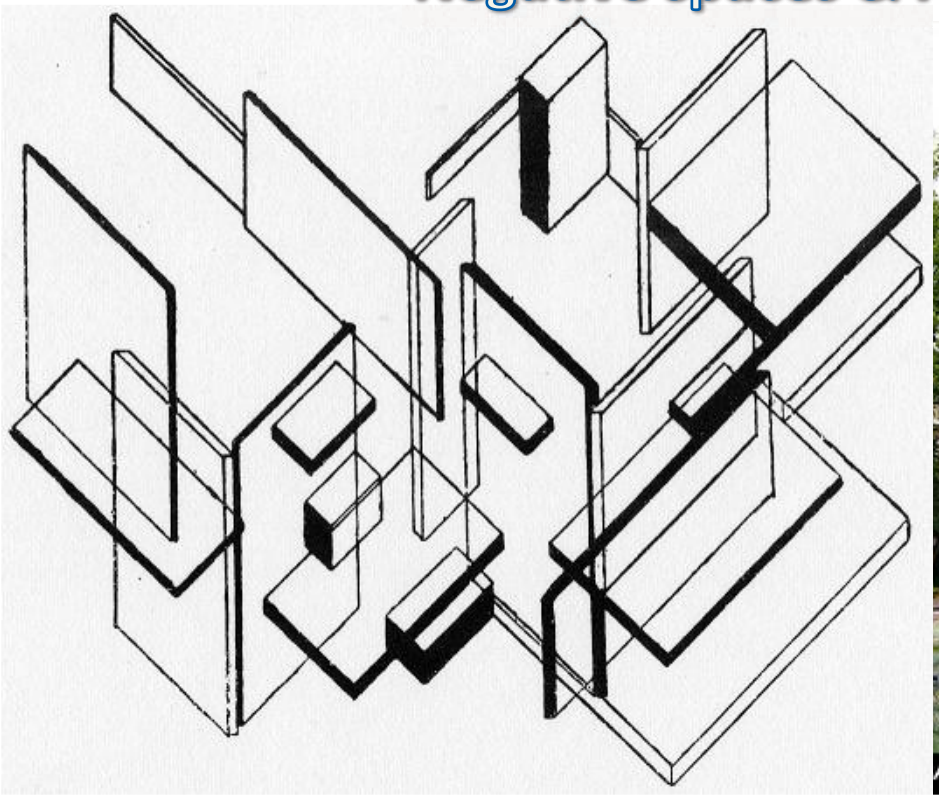


9.
La torre angolare principale è attratta verso la sua posizione attuale e il vettore esterno si piega per entrare nella corte.

Floor Plan : Säynätsalo Town Hall, Finland (1952) | Alvar Aalto

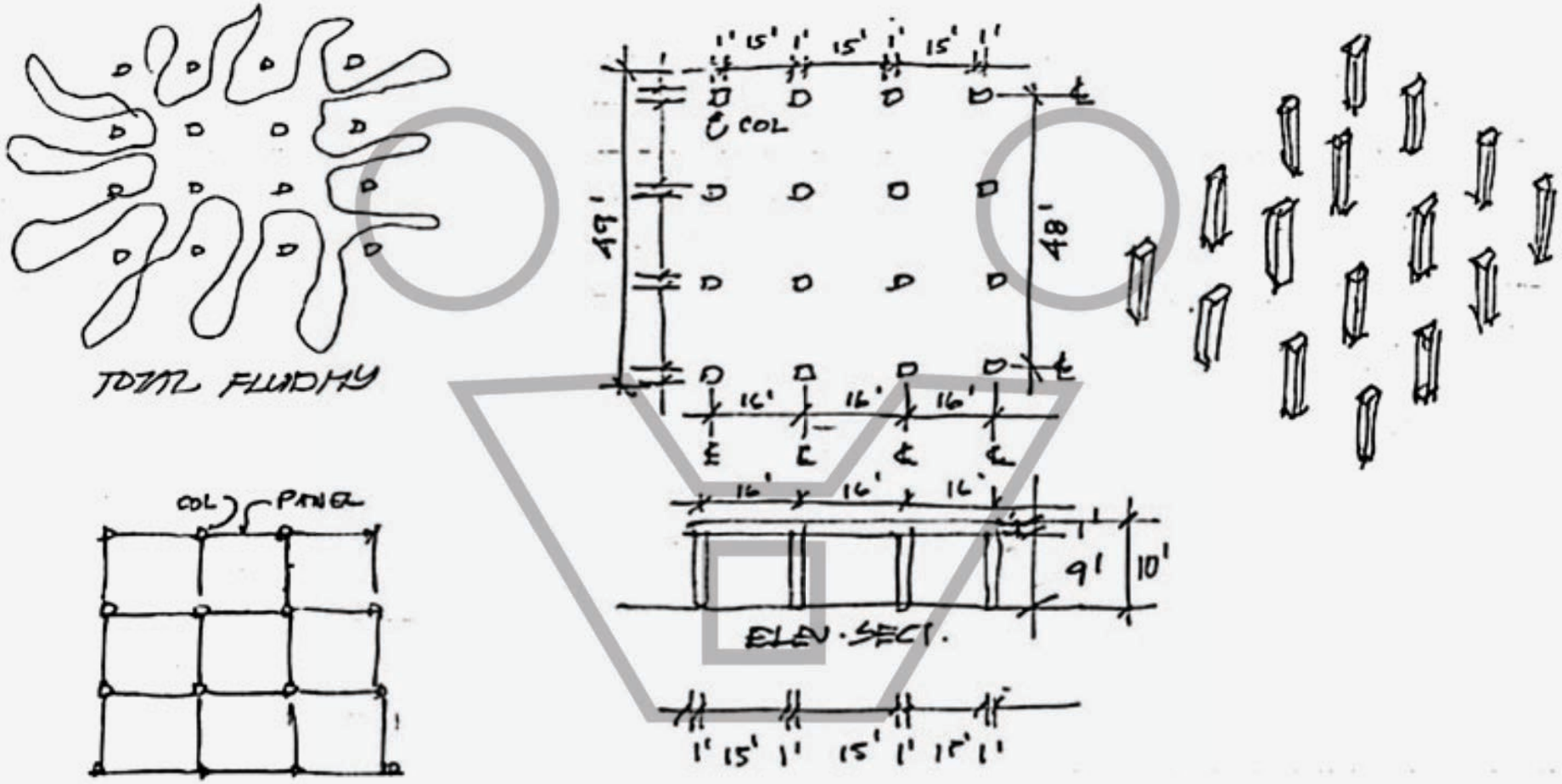
Floor Plan : Säynätsalo Town Hall, Finland (1952) | Alvar Aalto

Negative spaces & Flat surfaces in movement



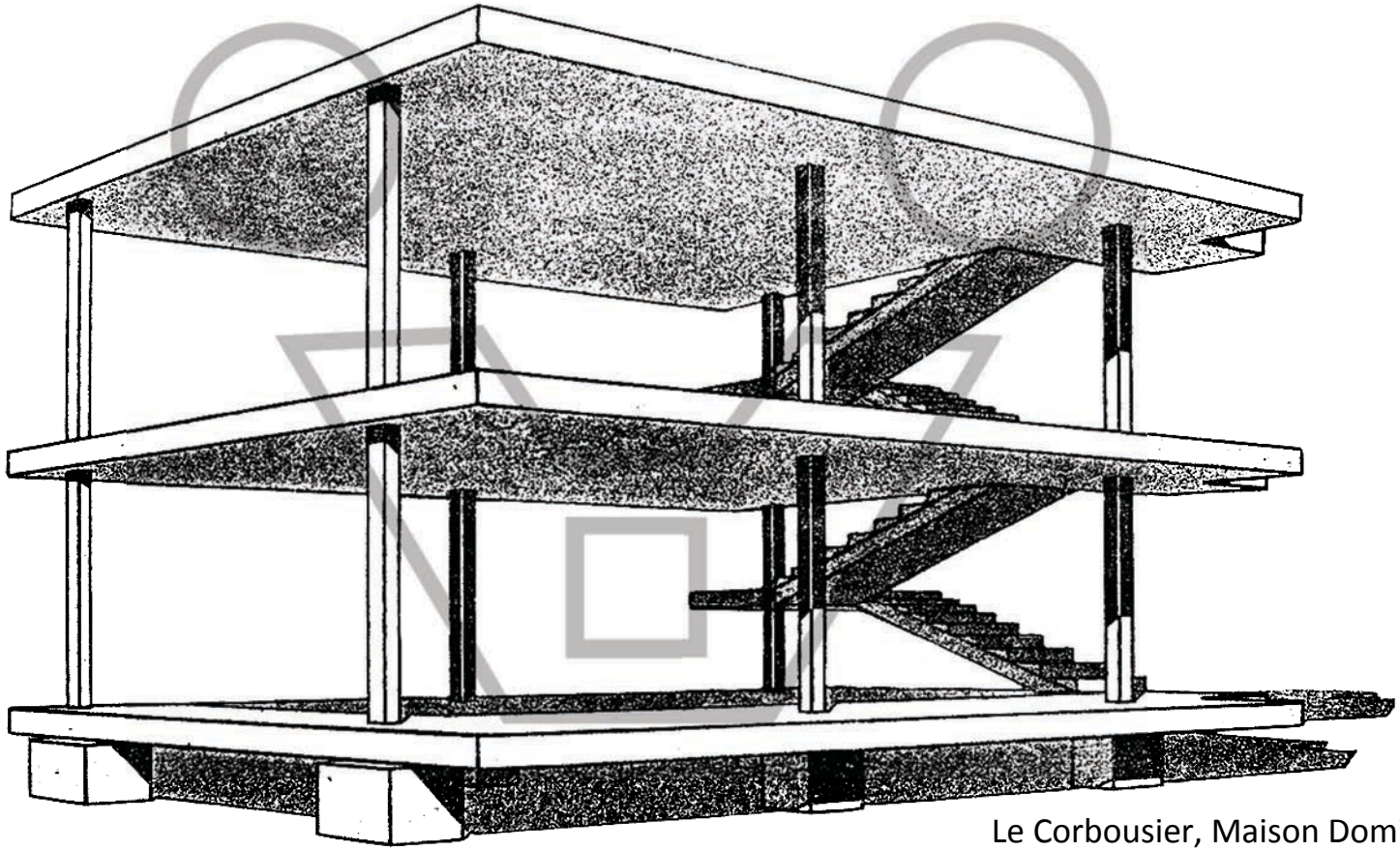
Theo_van_Doesburg,_Architectuuranalyse, 1923

Damian Ortega’s Cosmic Thing



Initial instructions for the 9-square-grid exercise.

Structural Frame and the "Plan Libre"

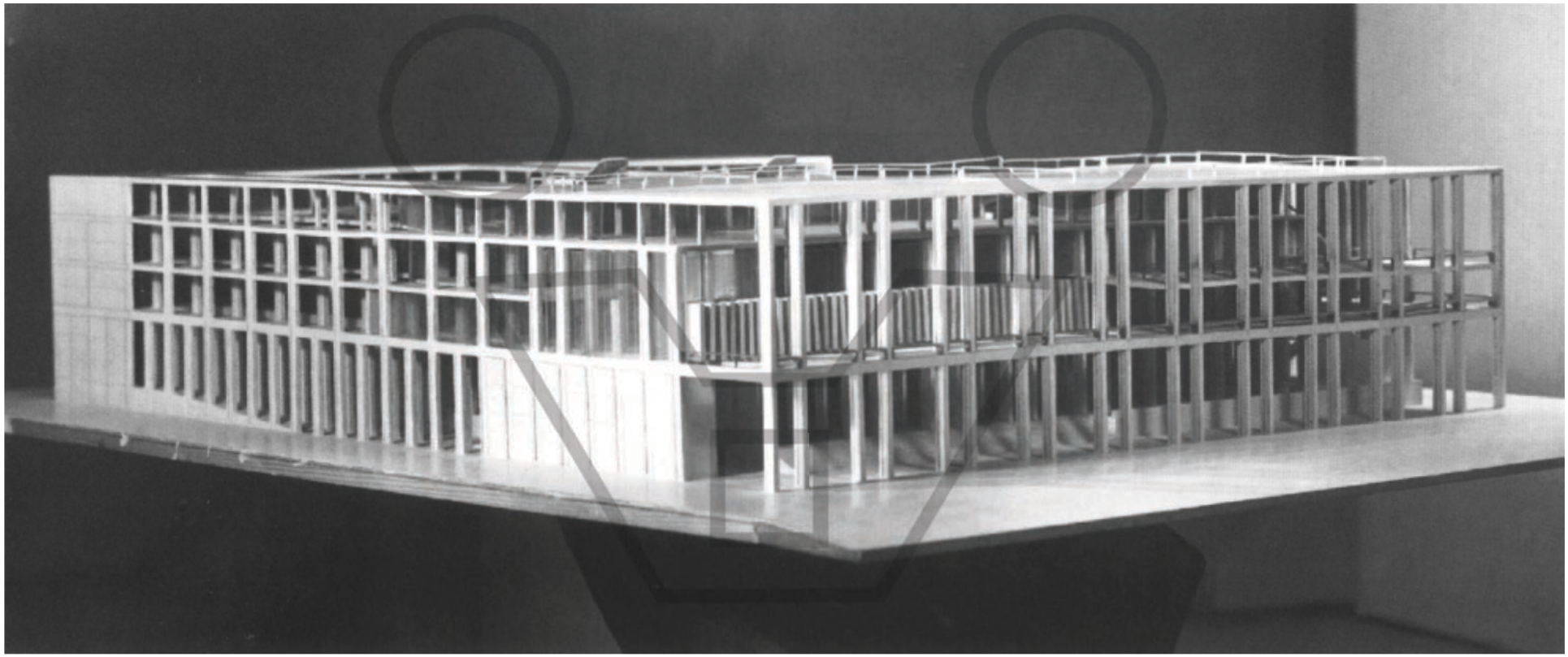


Le Corbousier, Maison Domino, 1914

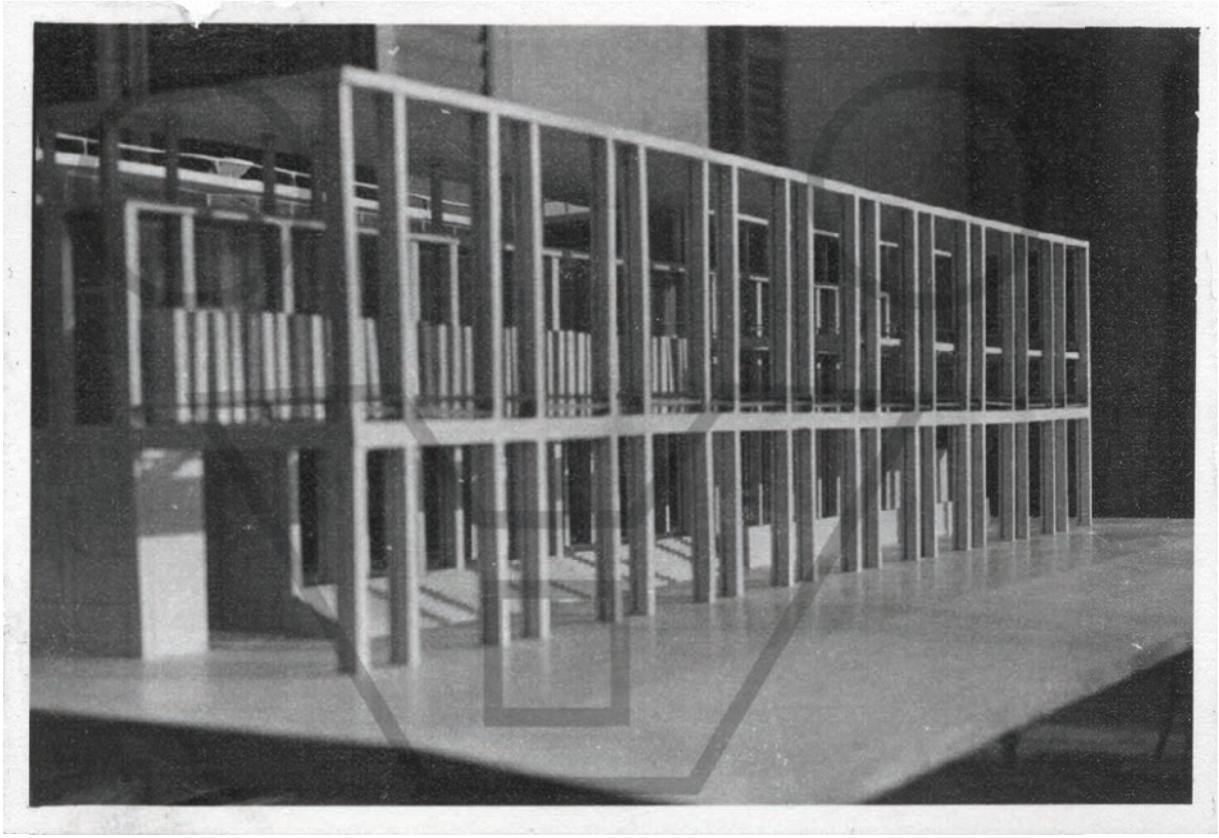
Structural frame as architectural language
1950 illinois farnsworth, mies

1950 illinois farnsworth mies van der rohe

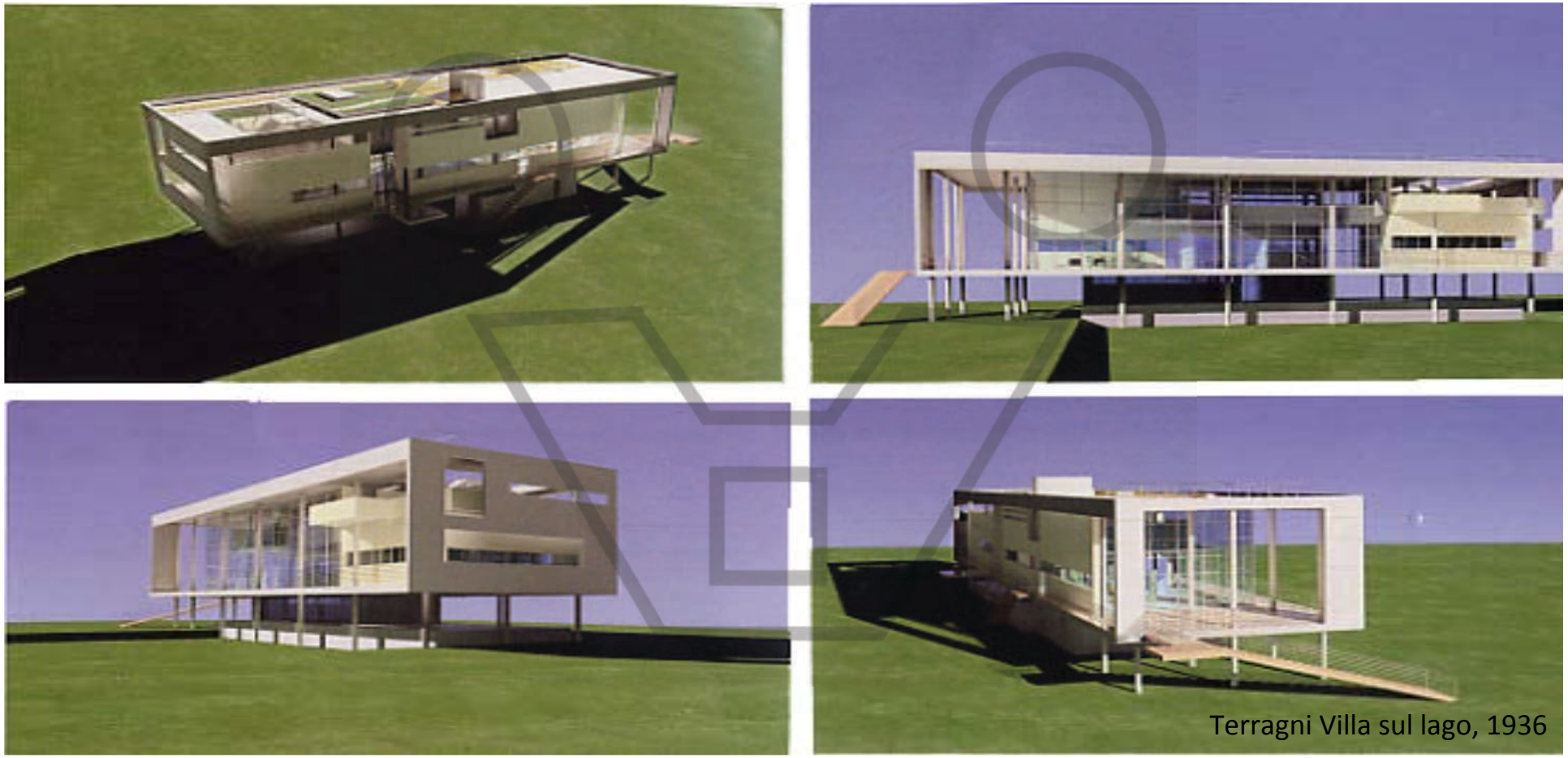
Johnson Glass House Philip Johnson House, New Canaan, CT (1949), Philip Johnson.jpg



Progetto per il Palazzo dei Ricevimenti e dei Congressi all'E.42, concorso nazionale ([1937] ... Autori: Pietro Lingeri con Cesare Cattaneo e Giuseppe Terragni.



Progetto per il Palazzo dei Ricevimenti e dei Congressi all'E.42, concorso nazionale ([1937] ... Autori: Pietro Lingeri con Cesare Cattaneo e Giuseppe Terragni.



Terragni Villa sul lago, 1936

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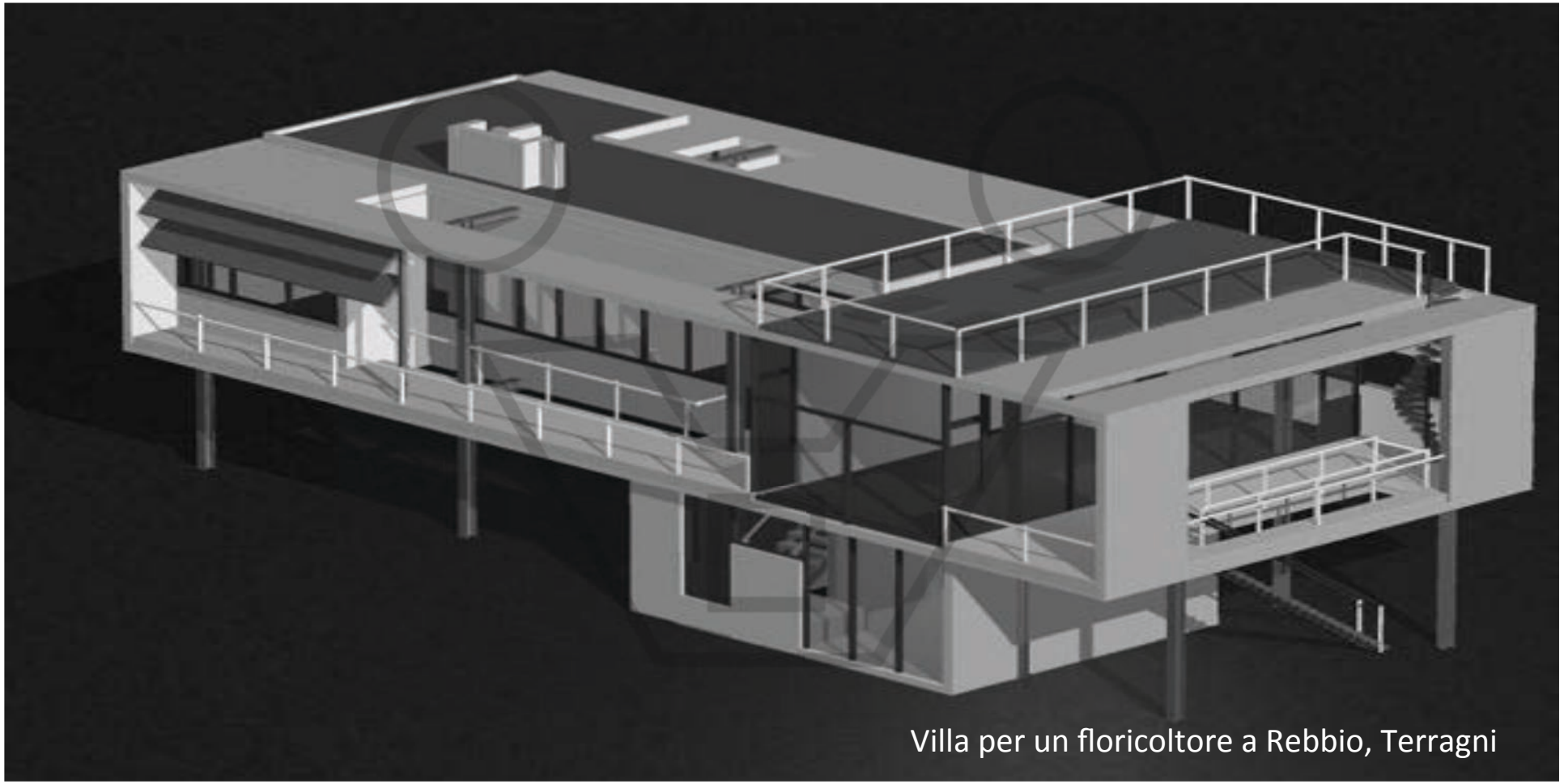
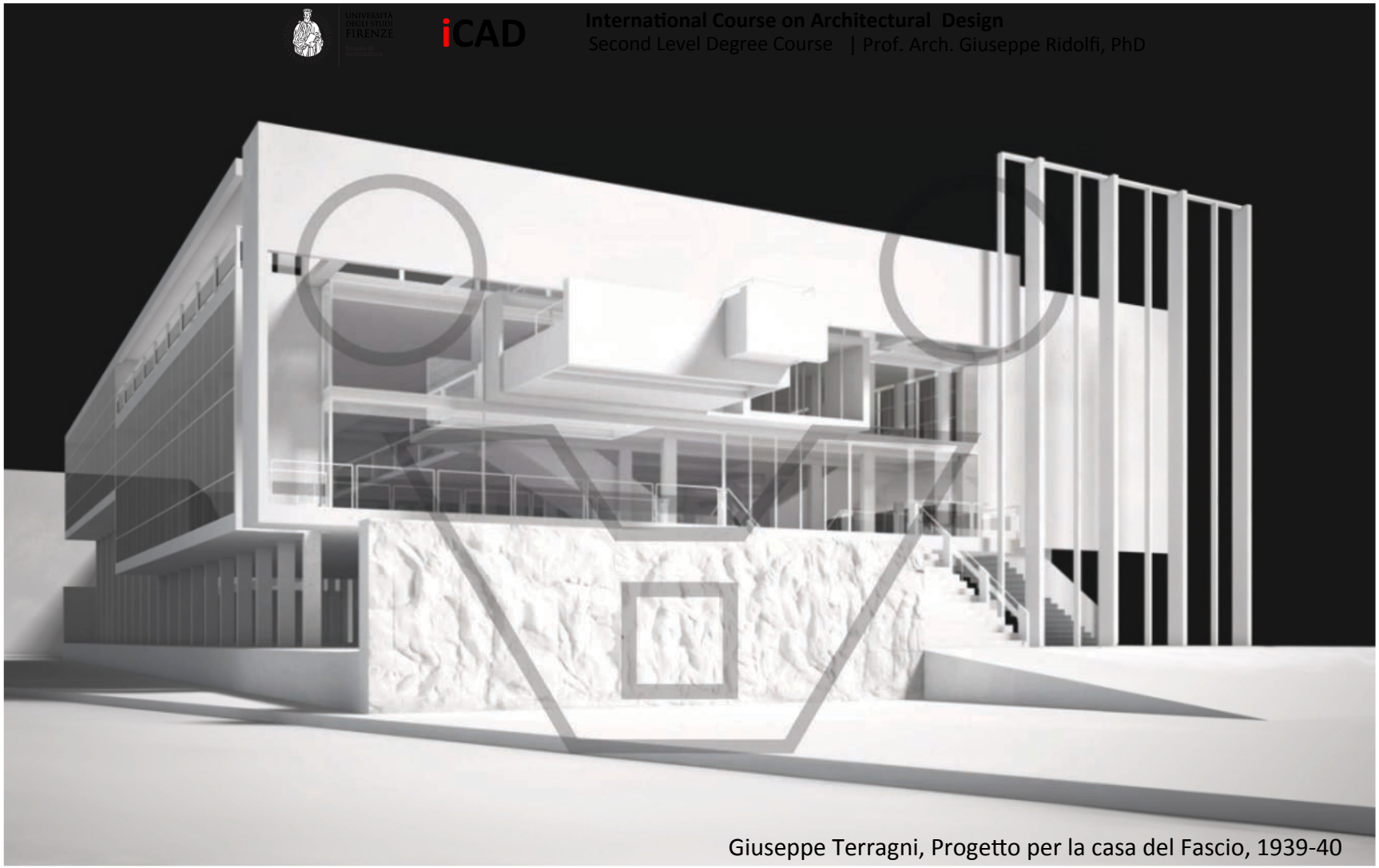


Villa per un floricoltore a Rebbio, Terragni

Terragni, Asilo Sant'Elia

Terragni, Asilo Sant'Elia



Giuseppe Terragni, Progetto per la casa del Fascio, 1939-40

R. Meyer, Bodrum Houses, 2007-2010, Yalikavak, Turkey

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Denton Corker MarshallDenton Corker Marshall

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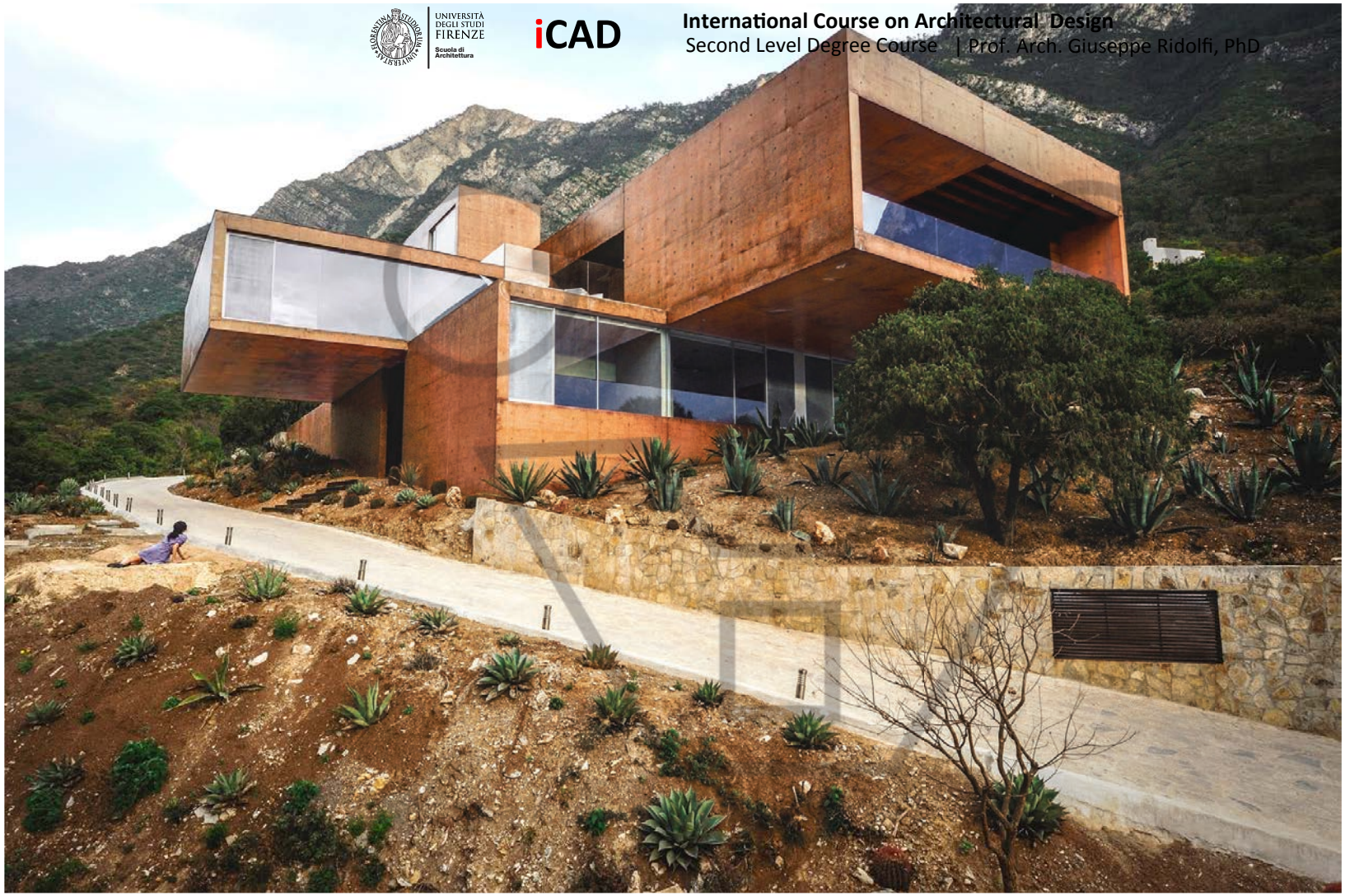

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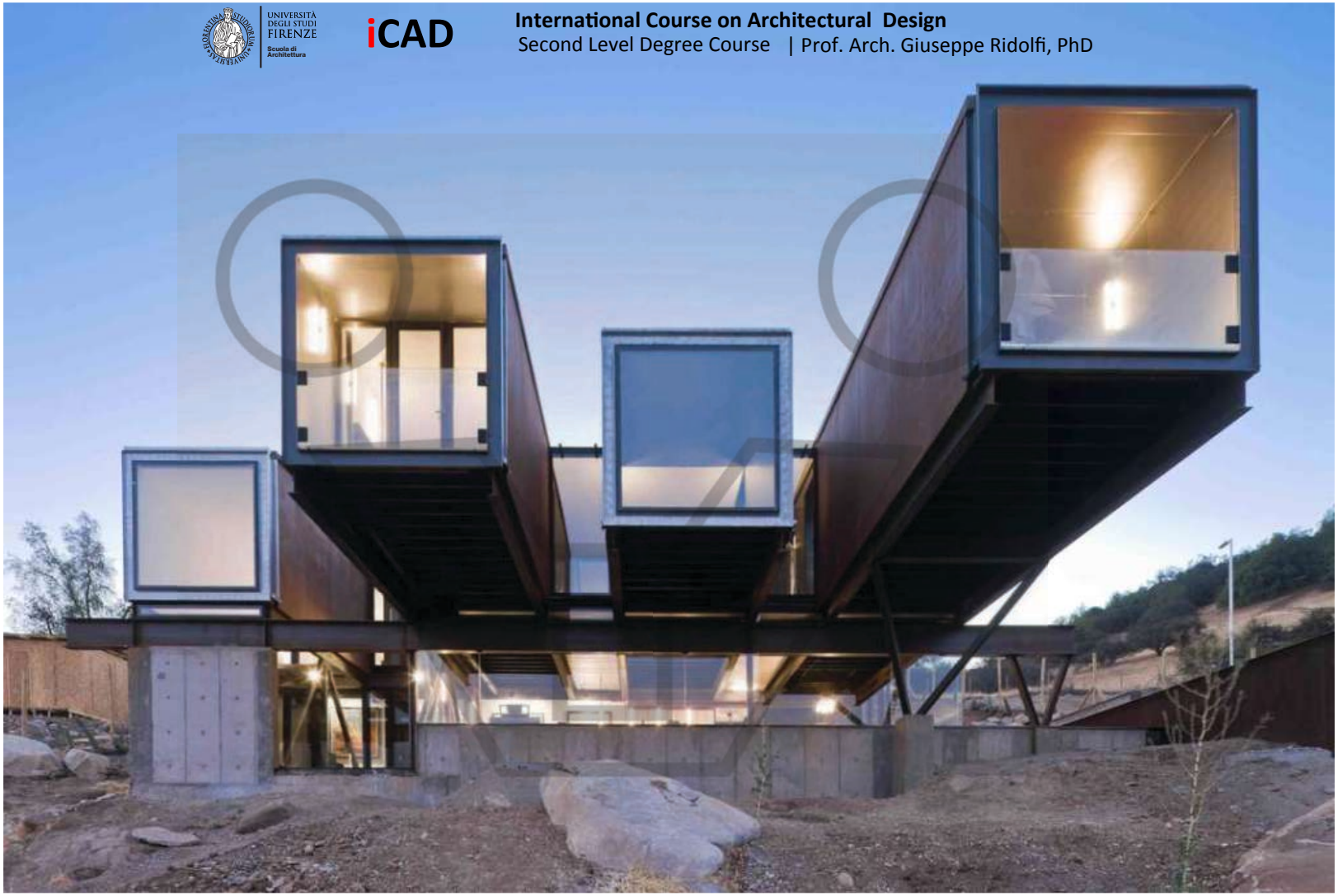

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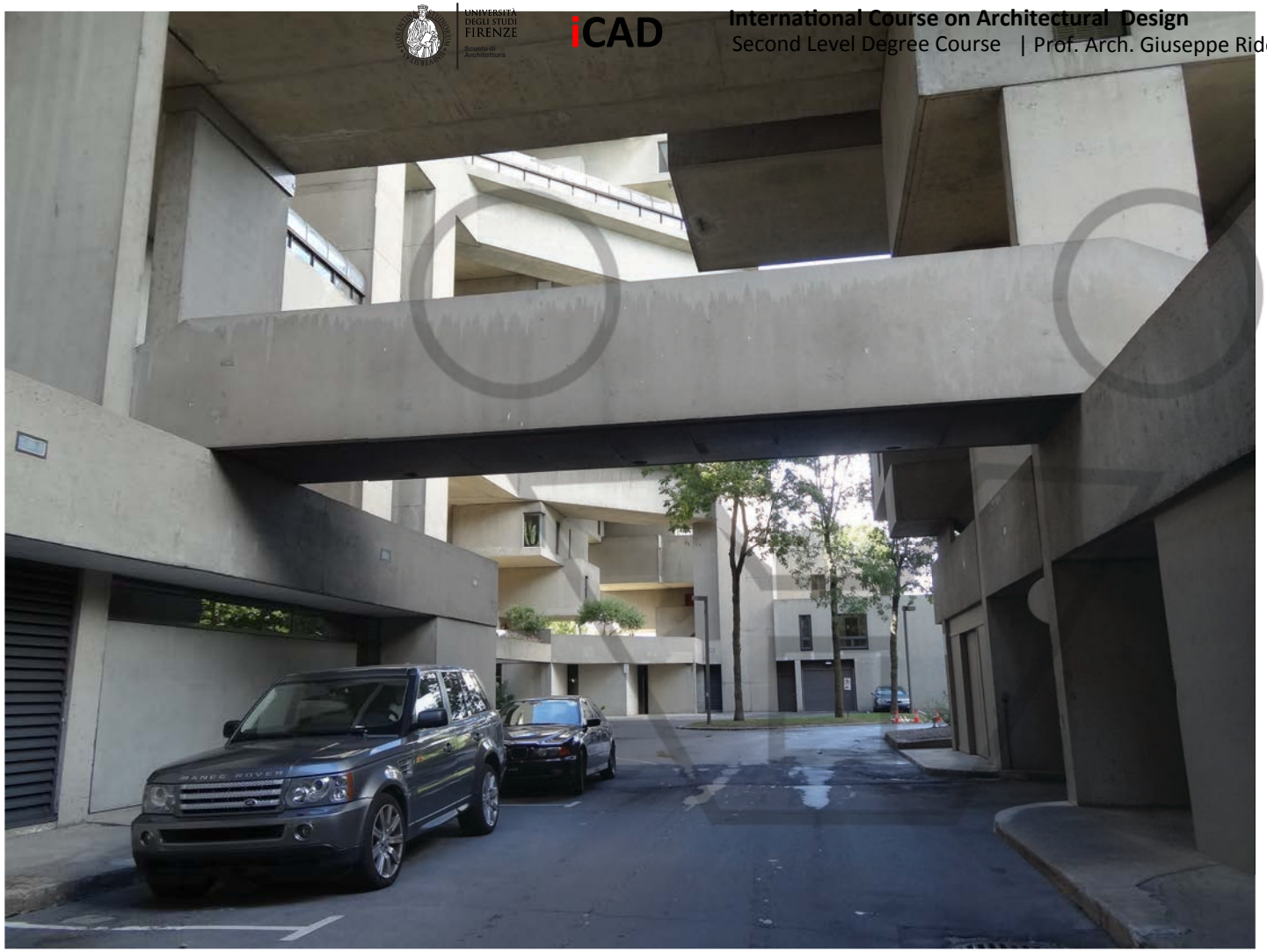
RANGE ROVER

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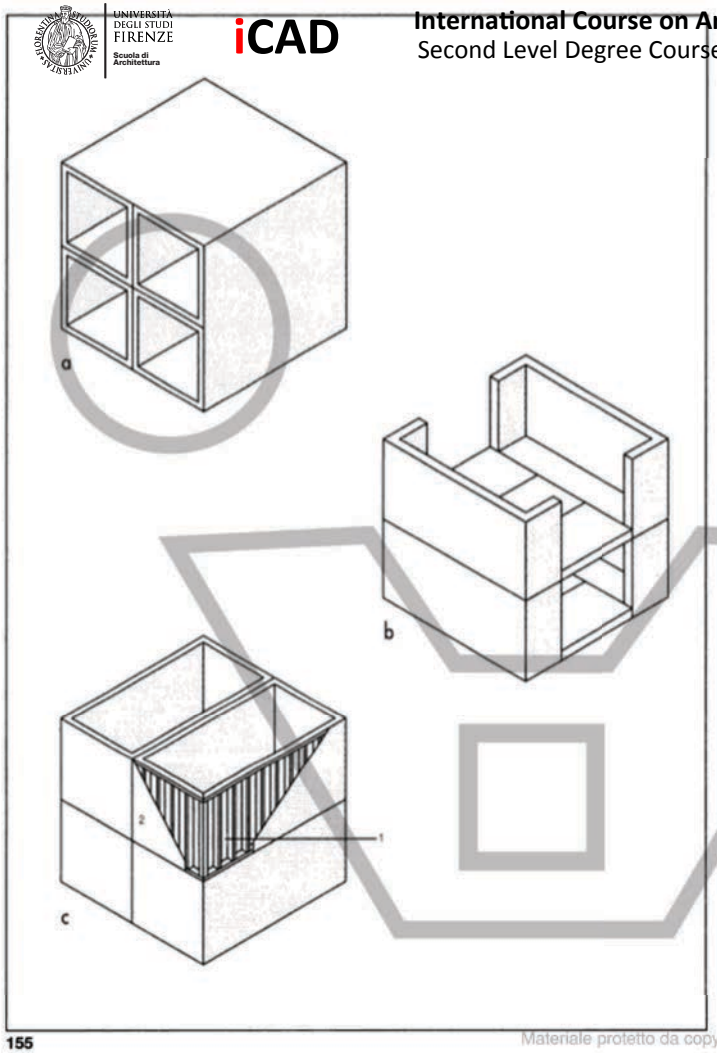

Fig. 153 *Tipologie dei componenti prefabbricati tridimensionali.*
Le strutture prefabbricate prevedono elementi standardizzati e tipologicamente definiti in funzione del numero e delle modalità di disposizione dei piani che li costituiscono; in tal senso si possono avere elementi aperti a L (a), a T (b) e a L rovescia (c), elementi semiaperti a U rovescia (d), a P greco rovescia (e), a U (f), elementi cellulari ad anello aperto (g), o chiuso (h).
Fig. 154 *Schemi tipologici di edifici realizzati con strutture tridimensionali.*
a) Schema di edificio con sviluppo prevalentemente longitudinale (edificio in linea realizzato con elementi a U rovescia).
b) Schema di edificio con sviluppo verticale e disposizione planimetrica più complessa (edificio a torre realizzato con elementi di tipo aperto e semiaperto).
c) Schema articolato (realizzato con procedimento costruttivo a tunnel).
Fig. 155 *Modelli funzionali delle strutture tridimensionali.*
a) Sistema strutturale di tipo cellulare in materiale continuo omogeneo.
b) Componenti complessi in materiale continuo omogeneo.
c) Componenti complessi costituiti da un'intelaiatura a maglia fitta di elementi monodimensionali (1) con uno strato strutturale collaborante (2).

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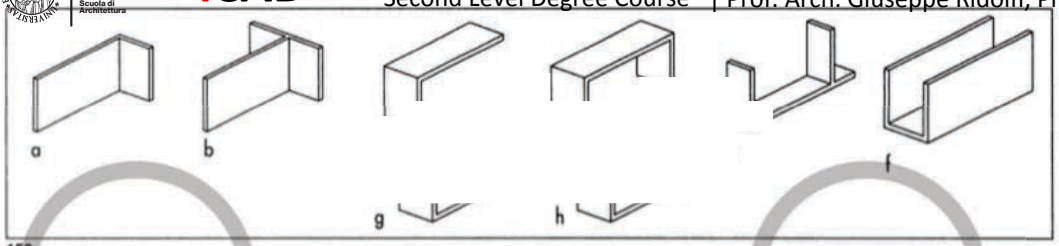

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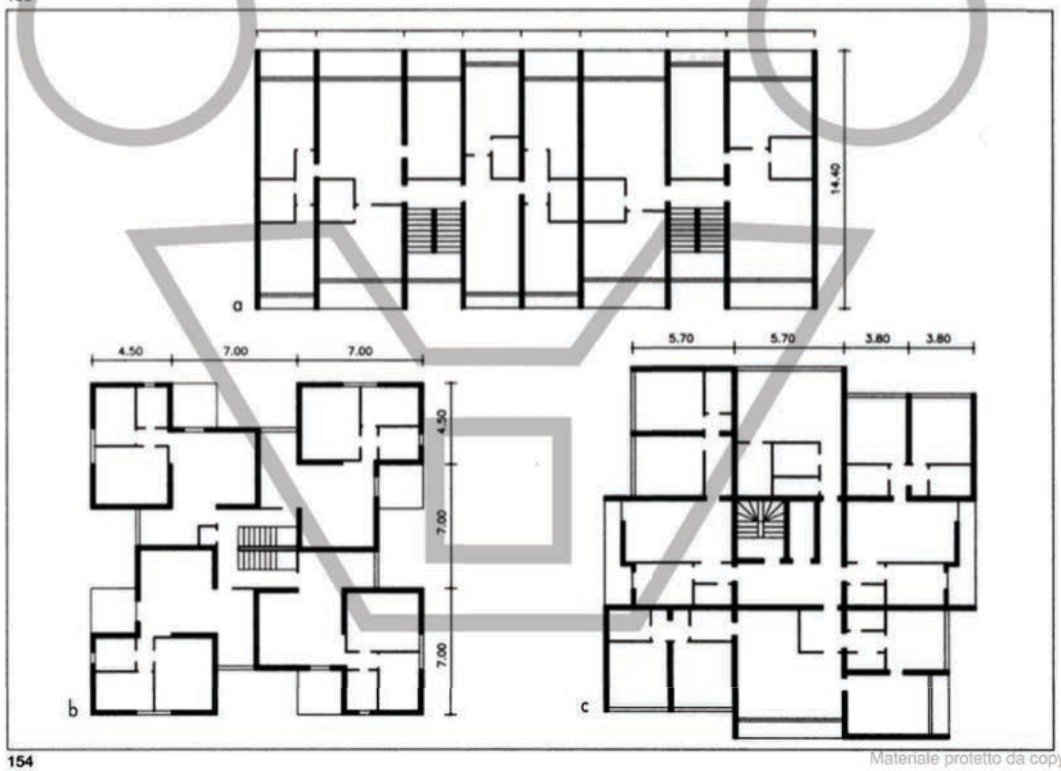

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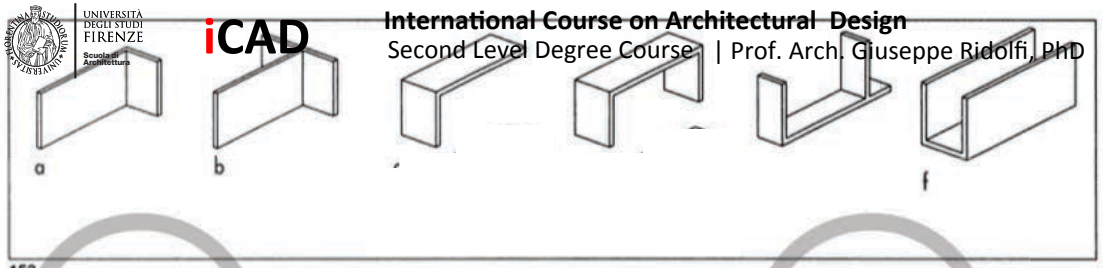
Triedro System



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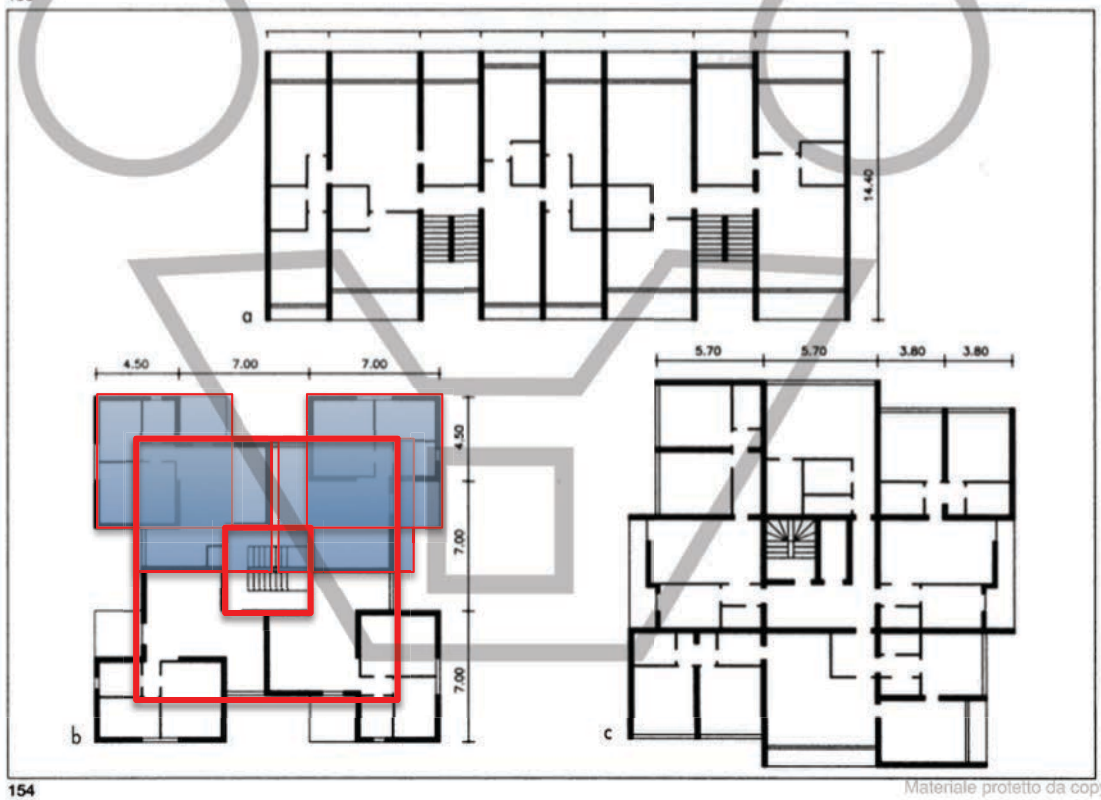

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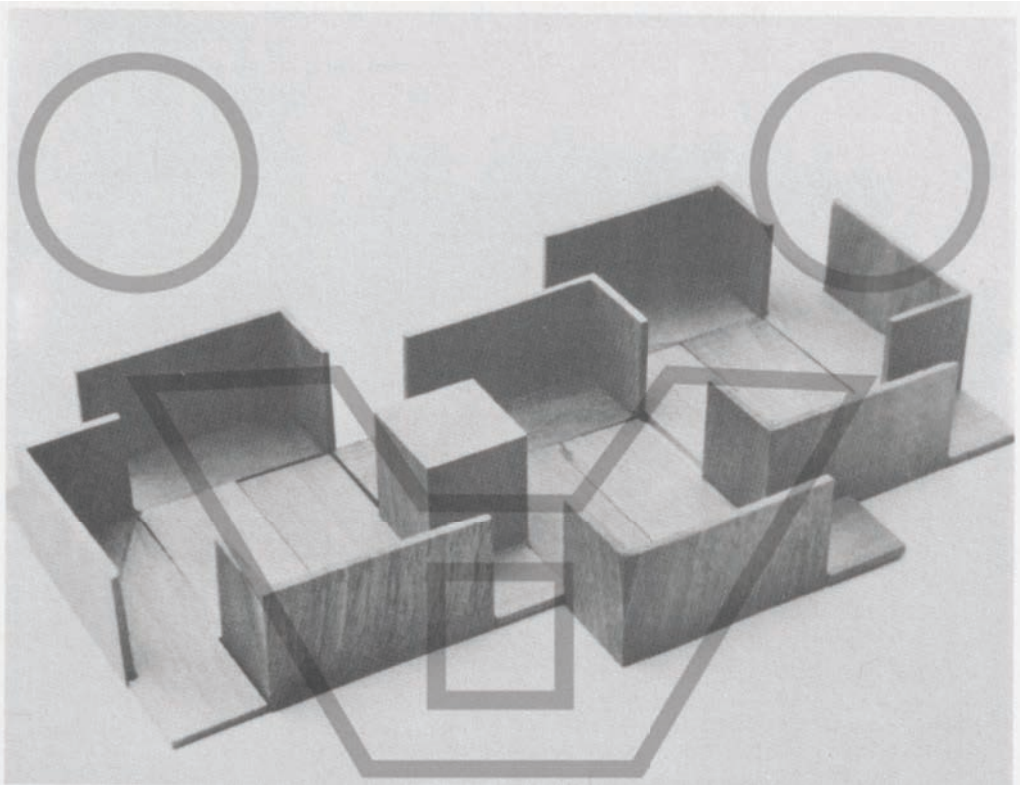
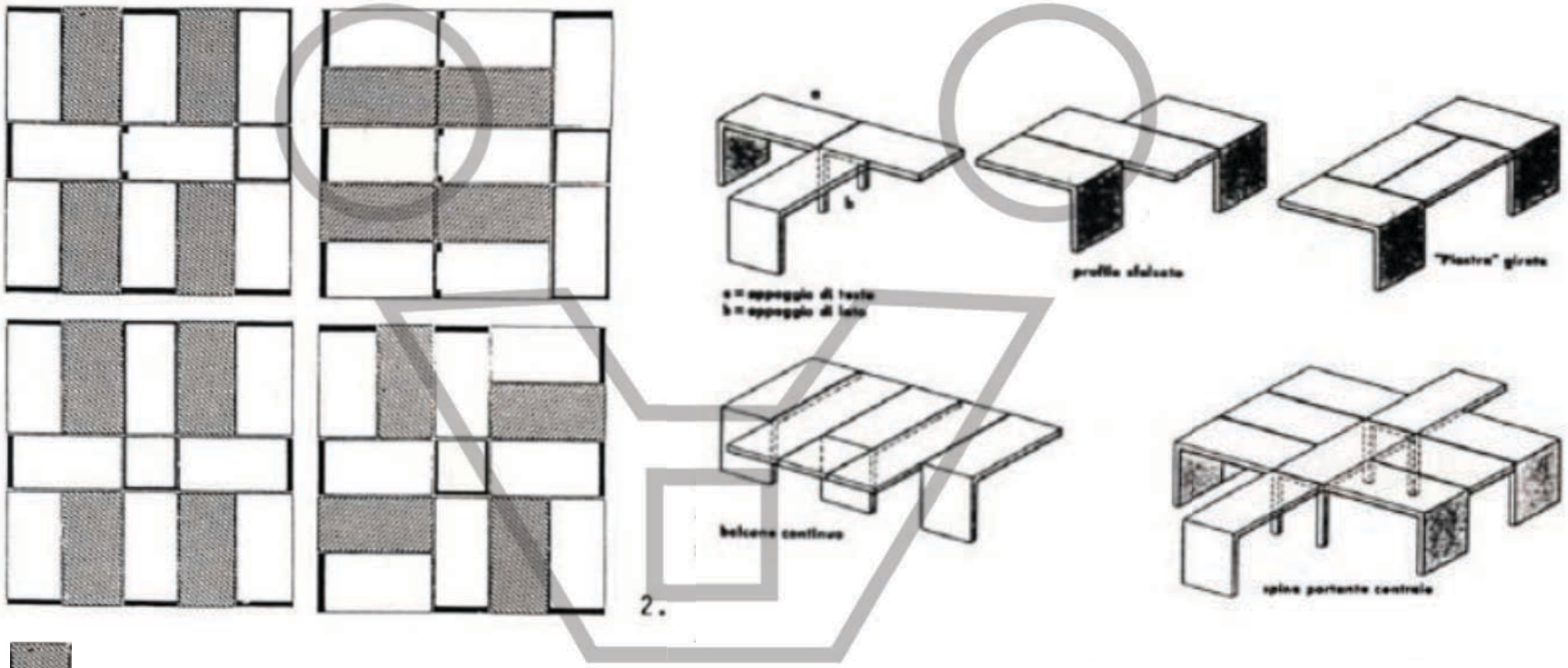
Materiale protetto da copyrig

Triedro System

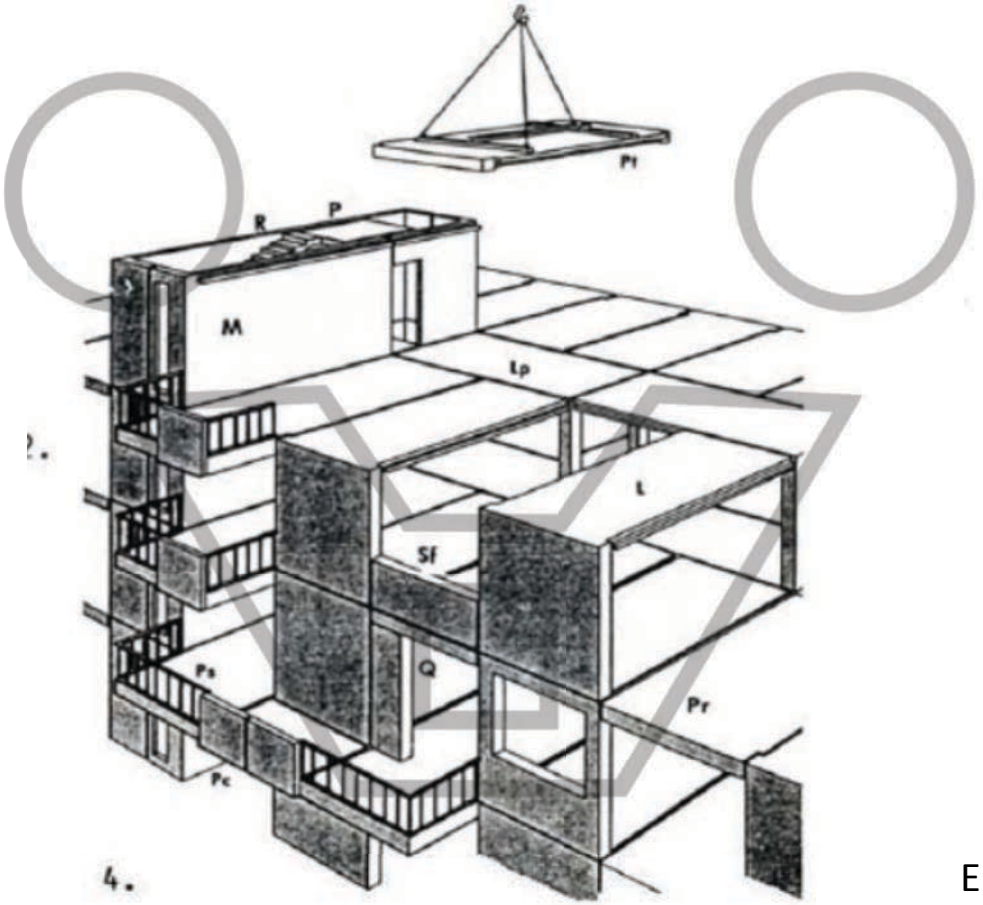


Triedro System



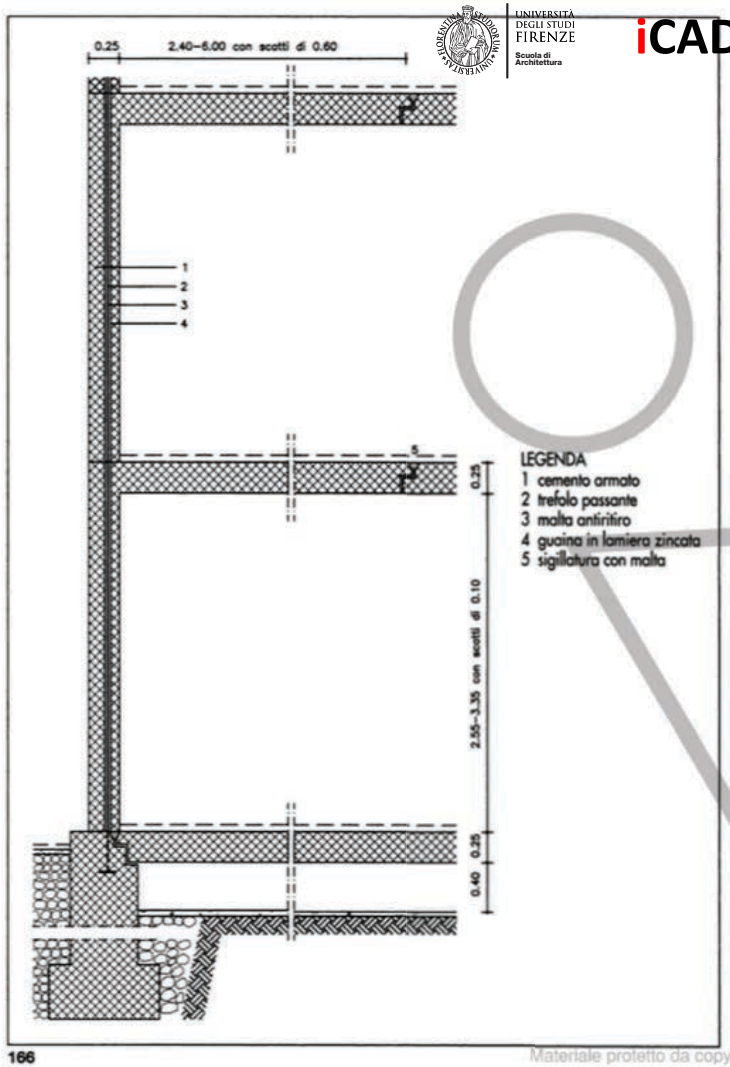
Not bearing element

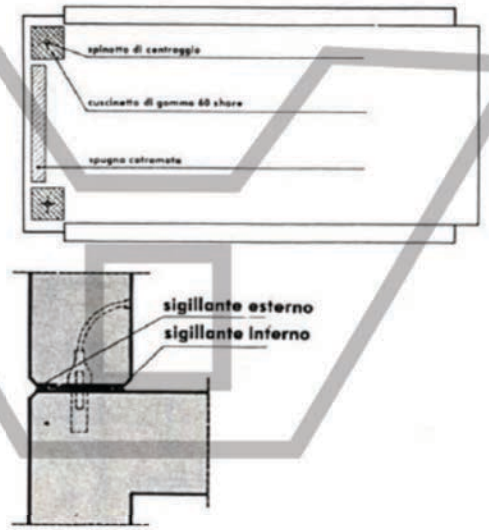
Elle System | Diagrammatic composition

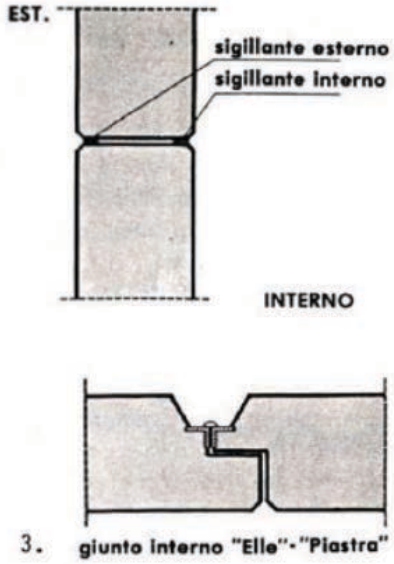


Elle System | Assembling

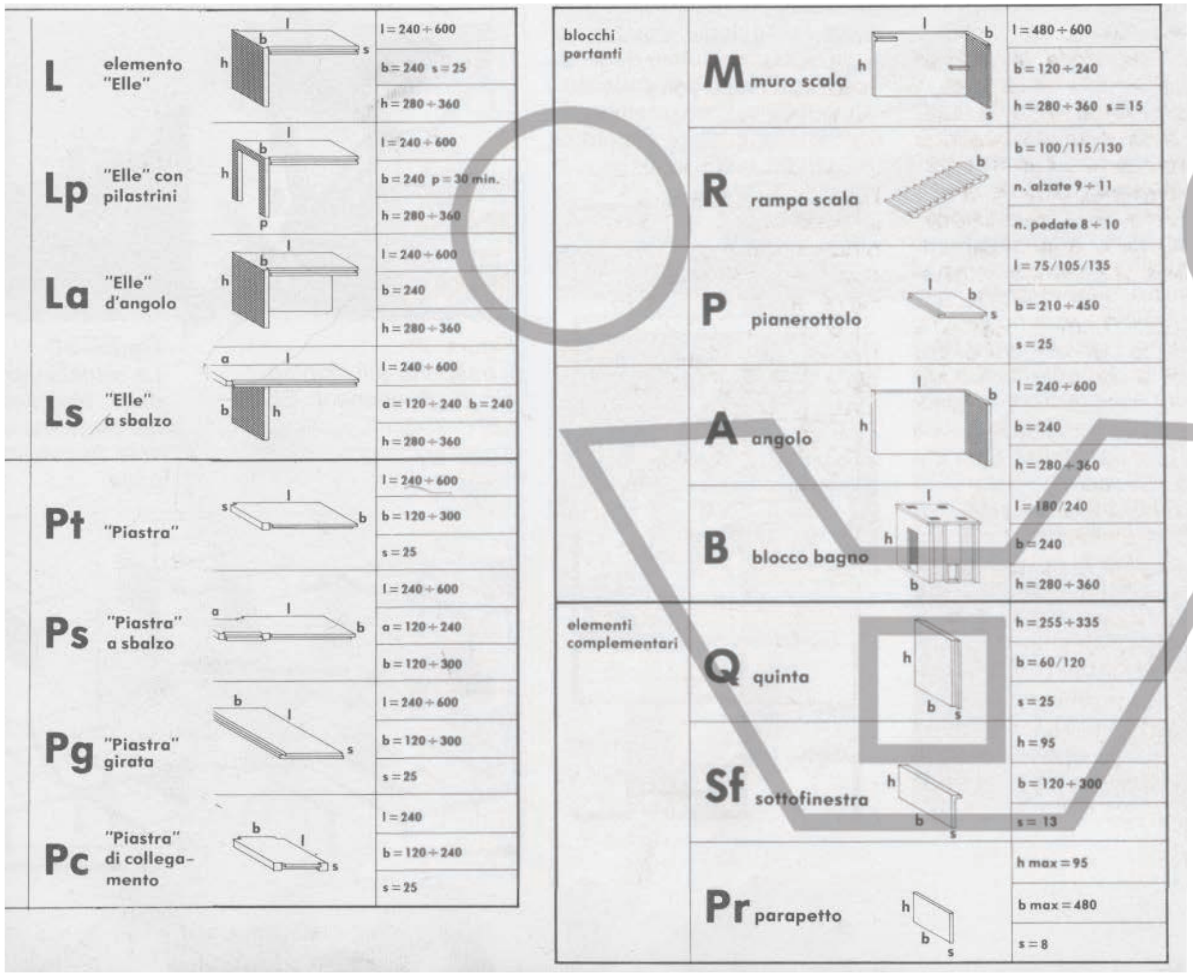
Elle System | Details







Materiale protetto da copyright



L	elemento "Elle"	l = 240 ÷ 600 b = 240 s = 25 h = 280 ÷ 360
Lp	"Elle" con pilastrini	l = 240 ÷ 600 b = 240 p = 30 min. h = 280 ÷ 360
La	"Elle" d'angolo	l = 240 ÷ 600 b = 240 h = 280 ÷ 360
Ls	"Elle" a sbalzo	l = 240 ÷ 600 a = 120 ÷ 240 b = 240 h = 280 ÷ 360
Pt	"Piastra"	l = 240 ÷ 600 b = 120 ÷ 300 s = 25
Ps	"Piastra" a sbalzo	l = 240 ÷ 600 a = 120 ÷ 240 b = 120 ÷ 300
Pg	"Piastra" girata	l = 240 ÷ 600 b = 120 ÷ 300 s = 25
Pc	"Piastra" di collegamento	l = 240 b = 120 ÷ 240 s = 25
blocchi portanti		
M	muro scala	l = 480 ÷ 600 b = 120 ÷ 240 h = 280 ÷ 360 s = 15
R	rampa scala	b = 100/115/130 n. alzate 9 ÷ 11 n. pedate 8 ÷ 10
P	pianerottolo	l = 75/105/135 b = 210 ÷ 450 s = 25
A	angolo	l = 240 ÷ 600 b = 240 h = 280 ÷ 360
B	blocco bagno	l = 180/240 b = 240 h = 280 ÷ 360
elementi complementari		
Q	quinta	h = 255 ÷ 335 b = 60/120 s = 25
Sf	sottofinestra	h = 95 b = 120 ÷ 300 s = 13
Pr	parapetto	h max = 95 b max = 480 s = 8

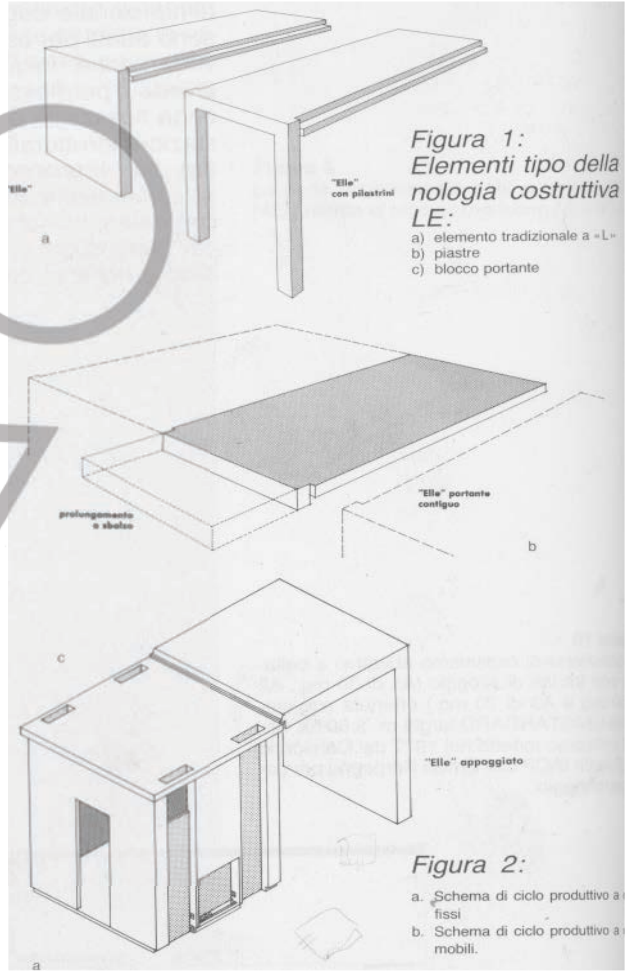
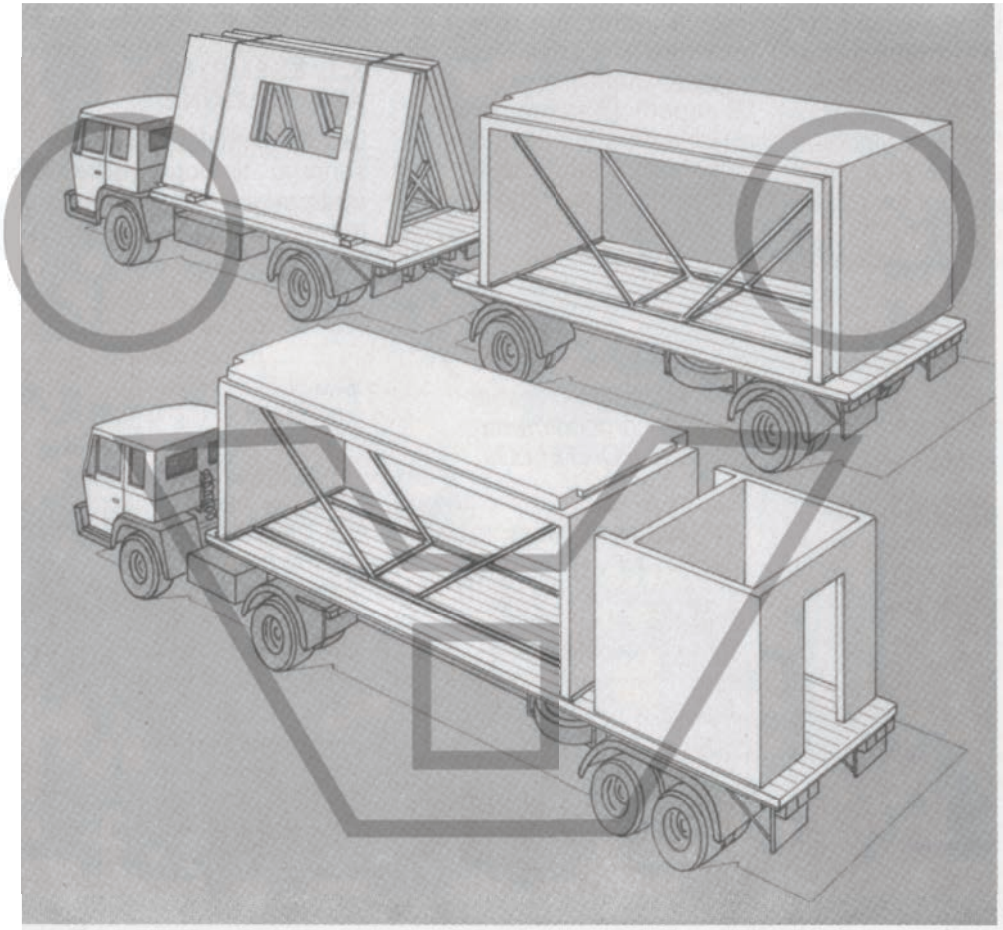


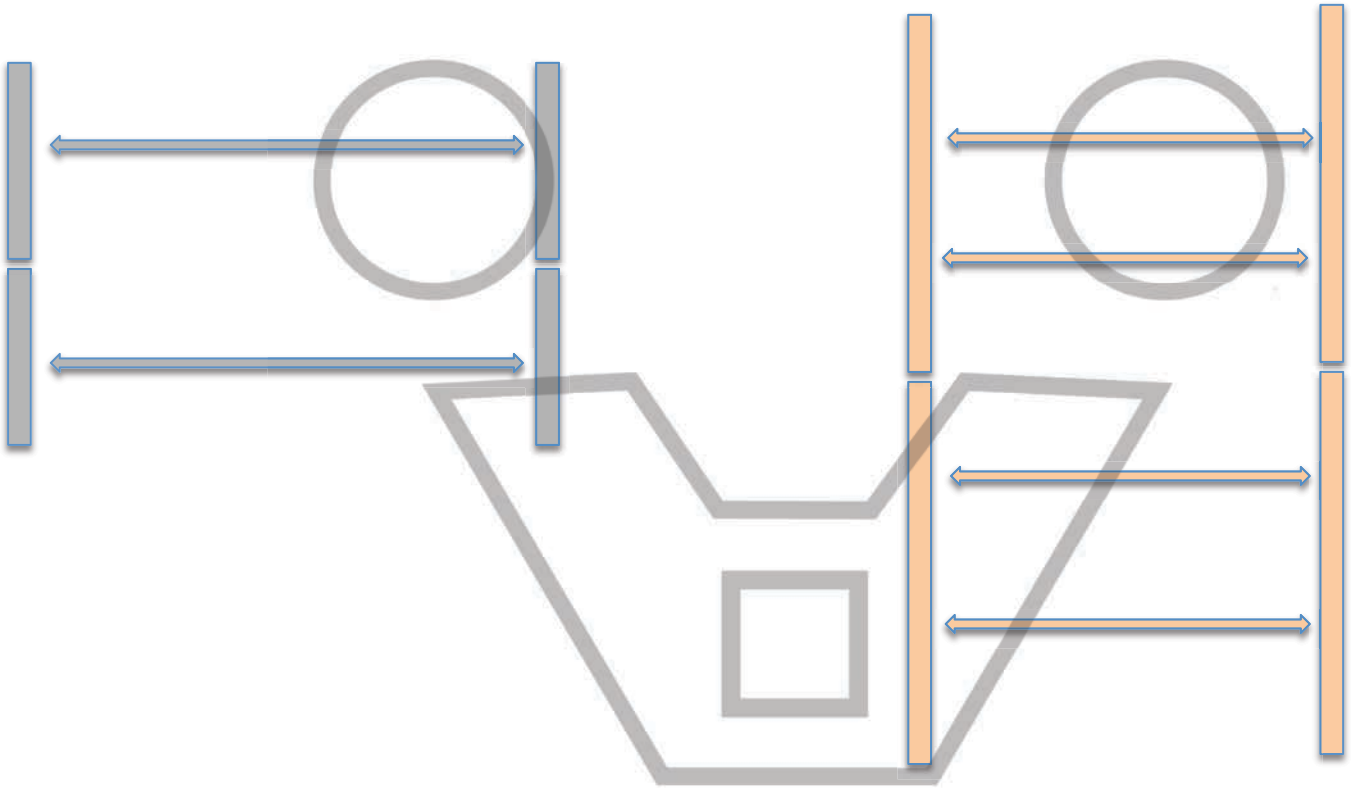
Figura 1:
Elementi tipo della nologia costruttiva LE:
a) elemento tradizionale a «L»
b) piastre
c) blocco portante

Figura 2:
a. Schema di ciclo produttivo a fissi
b. Schema di ciclo produttivo a mobili.



Dolmen System- Transportation

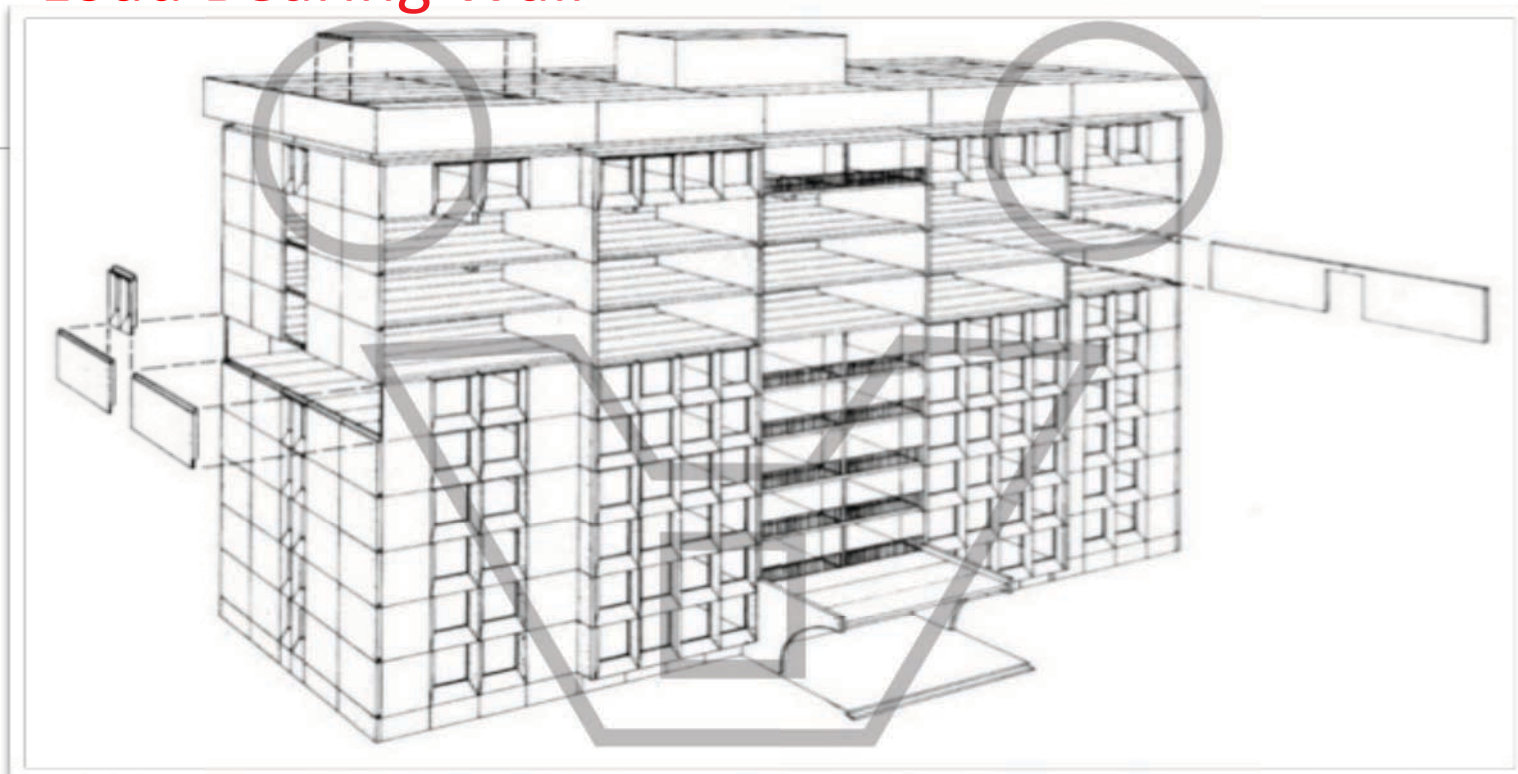
Technological Solutions
Rules of Thumb



CONCRETE=
short beam-long slab

STEEL=
long beam-short slab

Load Bearing Wall



Hollow core slabs supported on load bearing walls

PRECAST, PRESTRESSED CONCRETE STRUCTURAL ELEM

Precast Concrete Columns and Wall Panels

- Provide support for beam and slab elements.
- Since these elements carry mainly axial loads with little bending force, they may be conventionally reinforced without prestressing.
- Or, long, slender multistory elements may be prestressed to provide resistance to bending forces during handling and erection (columns at right).

Wall panels

- Prestressed or conventional reinforcement
- Used as load bearing walls
- Includes solid wall panels, hollow core wall panels and tee wall panels

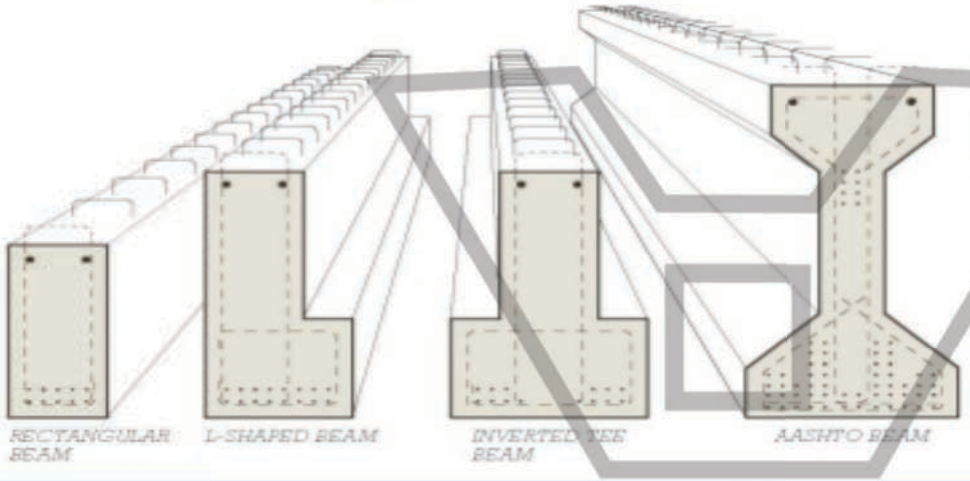
Beams

- Made in different sizes
- Rectangular beams, L shaped beams, inverted T beams and AASHTO beams

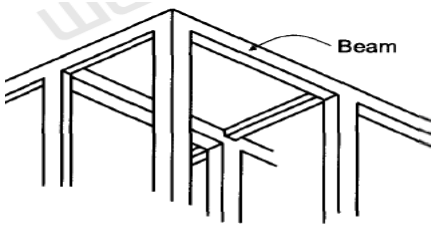
PRECAST, PRESTRESSED CONCRETE STRUCTURAL ELEM

Precast Concrete Beams and Girders

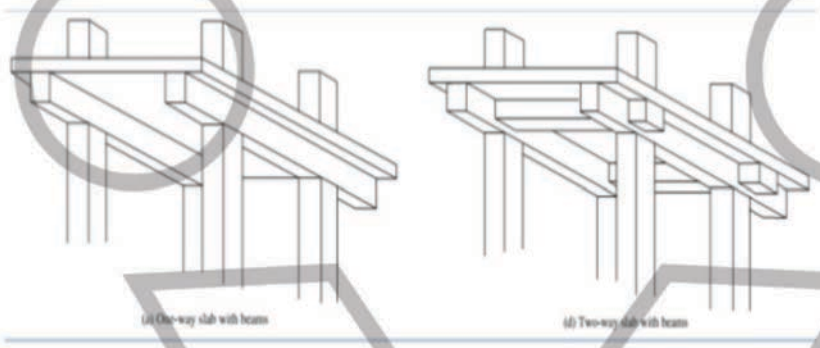
- Provide support for slabs.
- The projecting reinforcing bars will bond with concrete cast on site.
- Right: Inverted tee beams supported by precast columns.



The traditional solution

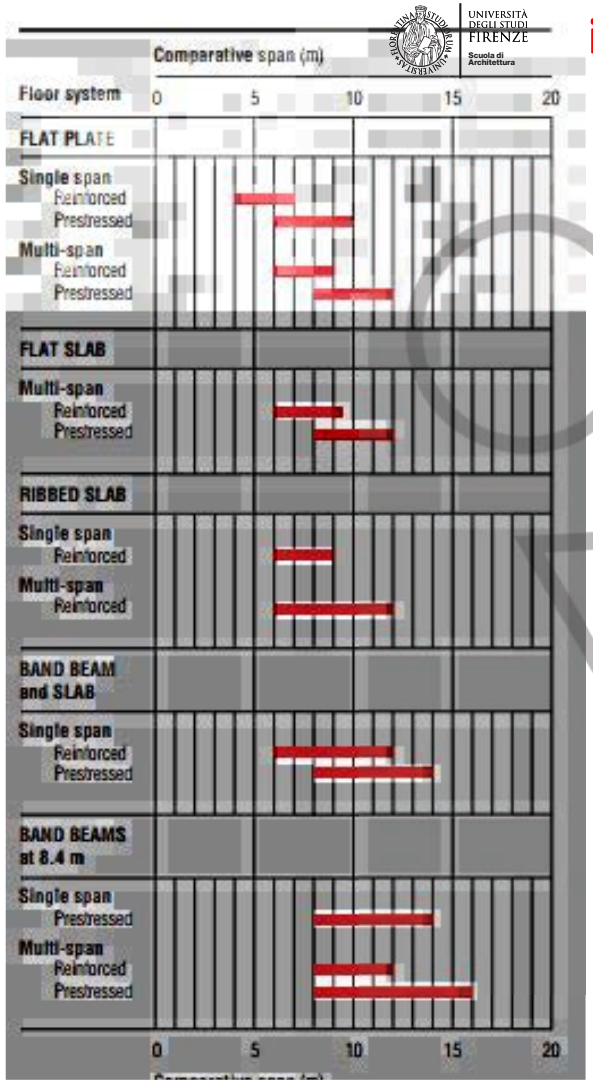


[e]

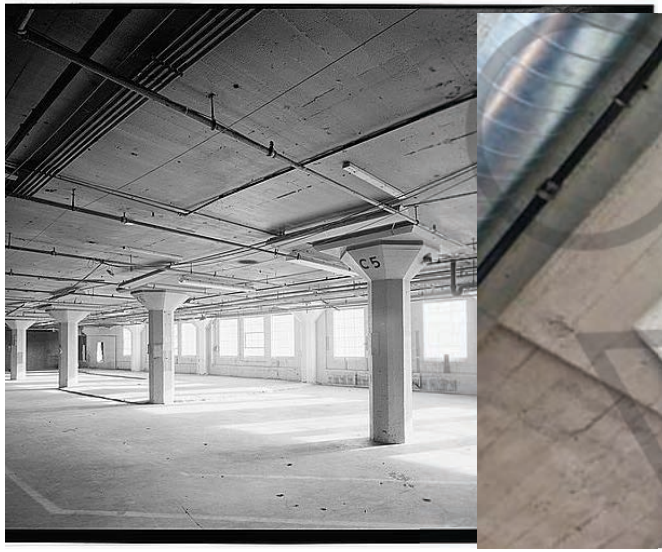


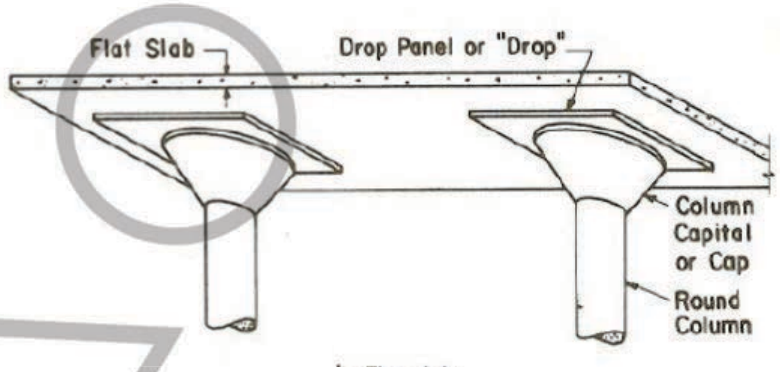
Beam and Slab This system consists of beams framing into columnsand supporting slabs spanning between the beams.It is a very traditional system. The relatively deep beams Provide a stiff floor capable of long spans, and able to resist lateral loads.
However, the complications of beam formwork, co-ordination of services, and overall depth of floor have led to a decrease in the popularity of this type of floor.

Luce [m]	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00
Trave a spessore b x h [cm]	25 x 12	34 x 12	42 x 12	50 x 12	60 x 14	68 x 16	75 x 18	84 x 20	92 x 22	100 x 24
Trave emergente b x h [cm]	30 x 15	30 x 20	30 x 25	30 x 30	30 x 35	30 x 40	30 x 45	30 x 50	30 x 55	30 x 60



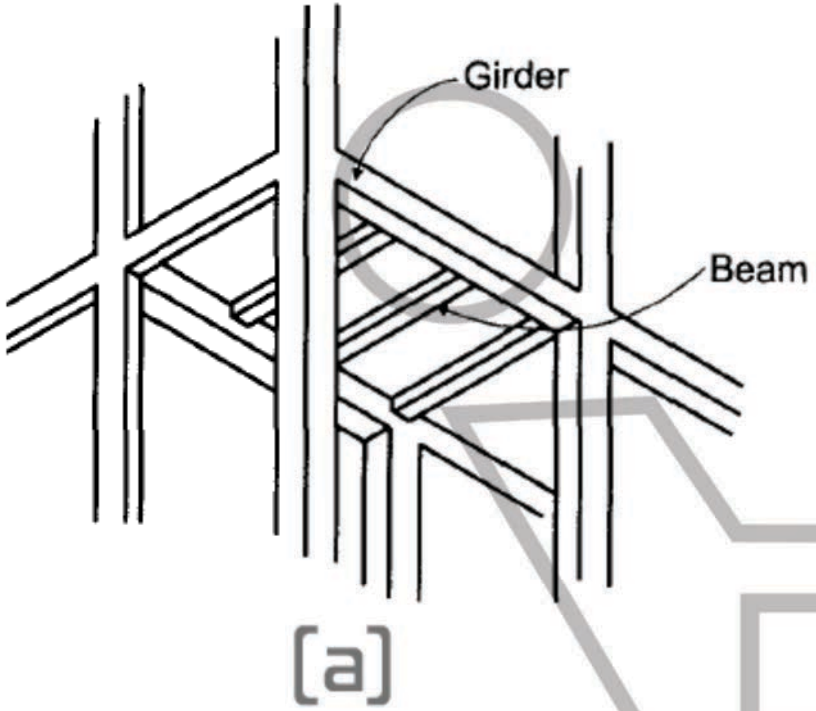
Comparative Span (m)
Quick selection guide for in situ concrete



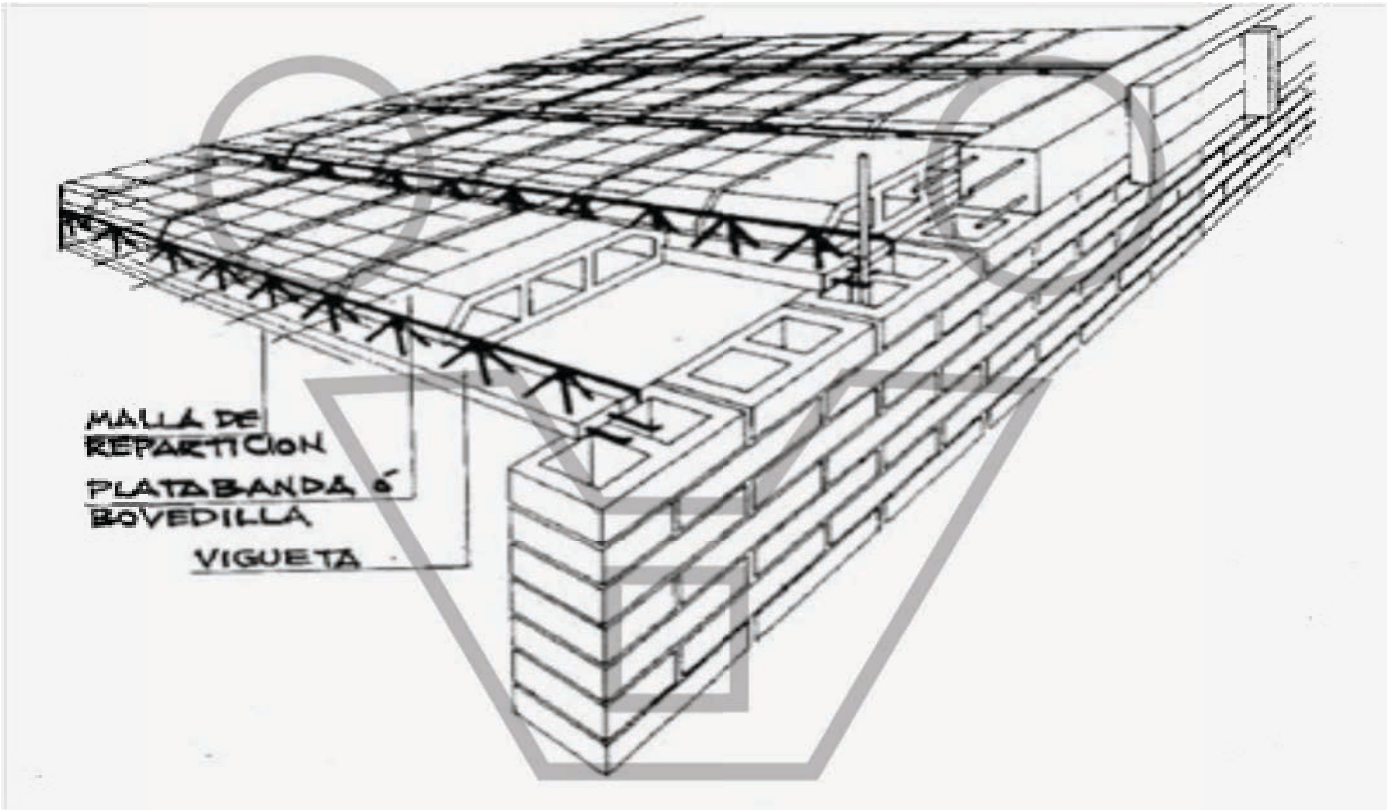


A flat slab is a one-way or two-way system with thickenings in the slab at the columns and loadbearing walls called ‘drop panels’

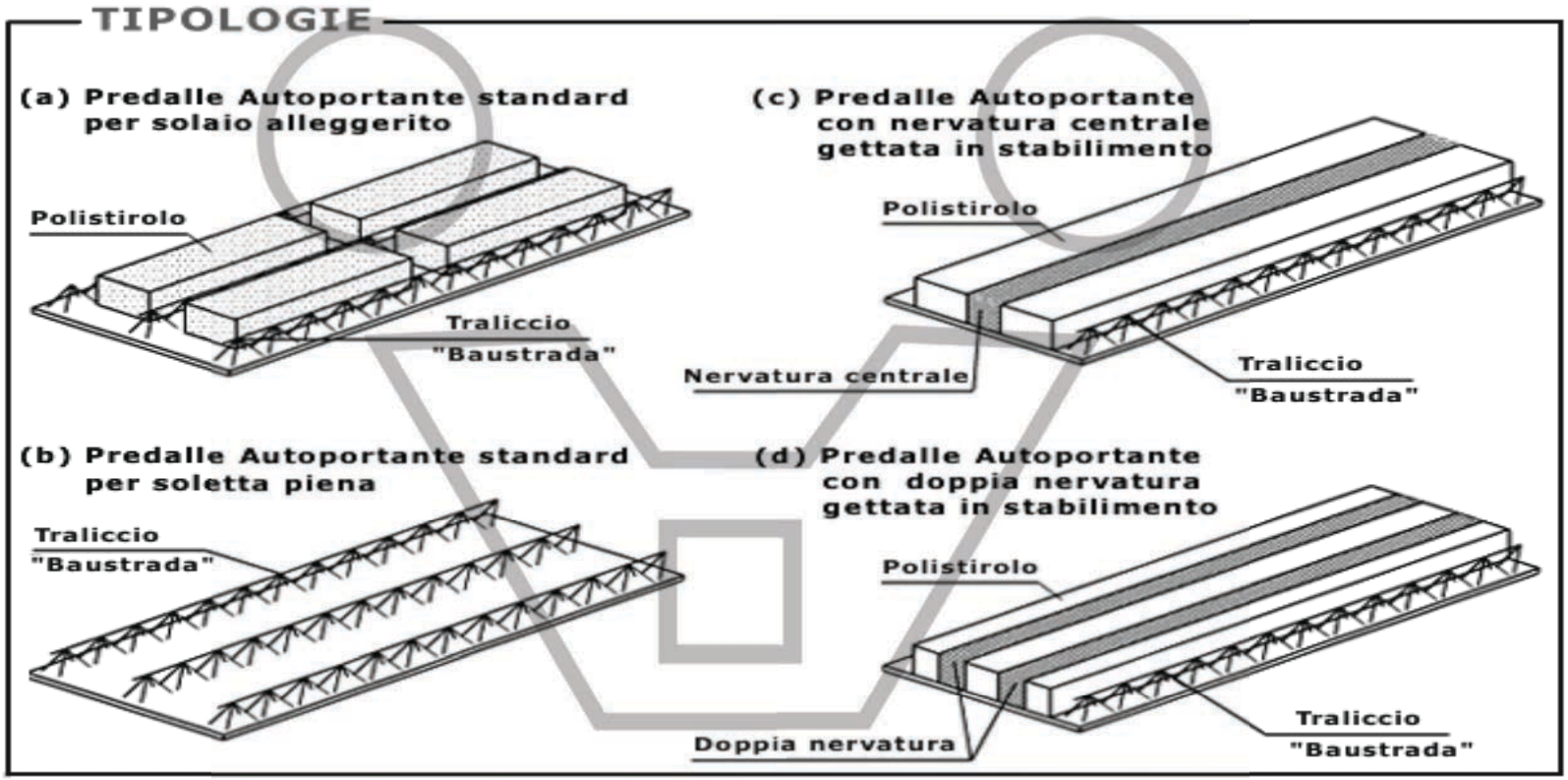
Ribbed/Waffle floors consisting of equally spaced ribs are usually supported directly by columns.
They are either one-way spanning systems known as **ribbed slab** or a two-way ribbed system known as a **Waffle slab**

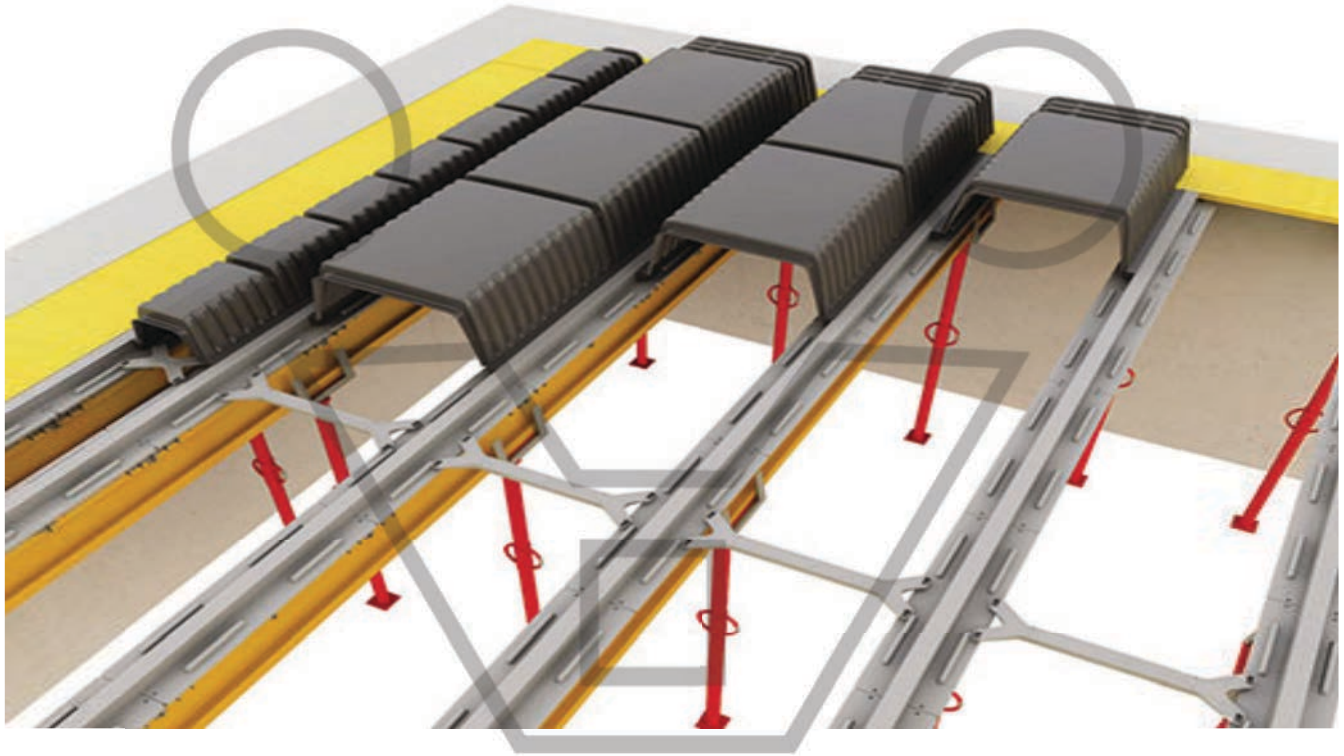


Grider and Beams

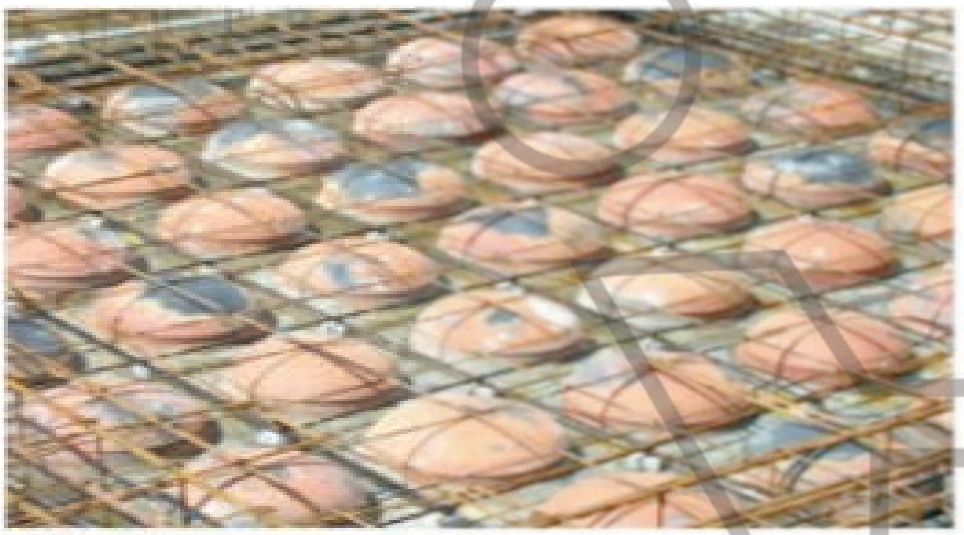

MALLA DE
REPARTICION
PLATABANDA ó
BOVEDILLA
VIGUETA

SAPALINO
Solaio per la ricostruzione


TIPOLOGIE
(a) Predalle Autoportante standard per solaio alleggerito
Polistirolo
Traliccio "Baustrada"
(c) Predalle Autoportante con nervatura centrale gettata in stabilimento
Polistirolo
Nervatura centrale
Traliccio "Baustrada"
(b) Predalle Autoportante standard per soletta piena
Traliccio "Baustrada"
(d) Predalle Autoportante con doppia nervatura gettata in stabilimento
Polistirolo
Doppia nervatura
Traliccio "Baustrada"



SKYRAIL: An Industrialized formwork for concrete



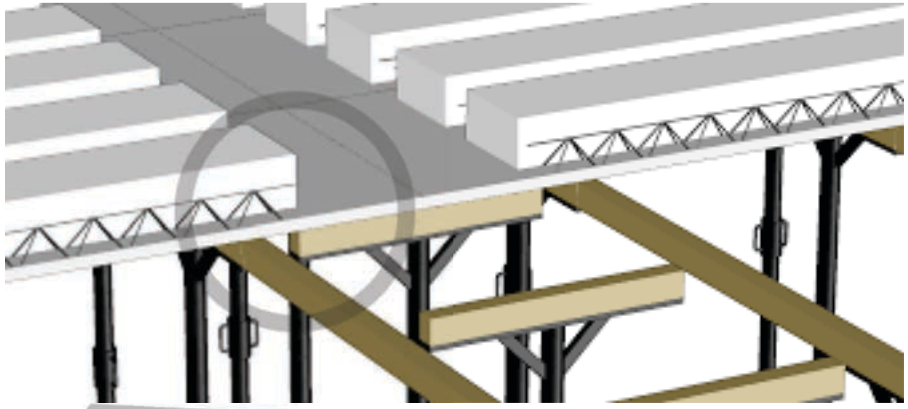
Earthen pots and Mangalore tiles used as filler materials between the steel reinforcements in the filler slabs

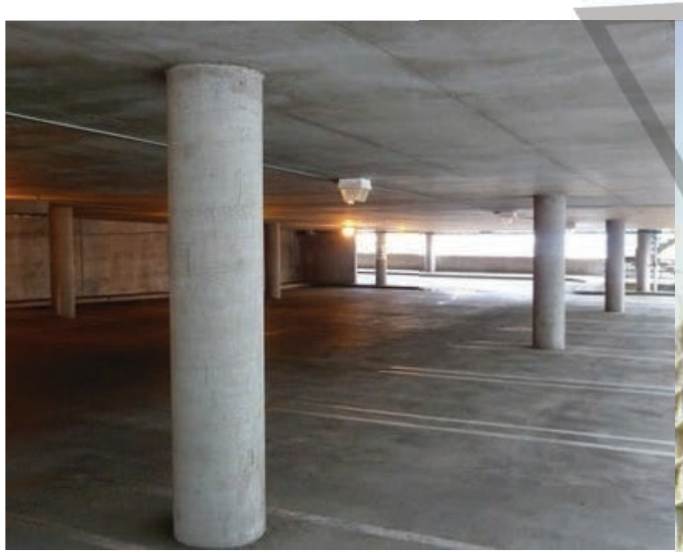
The semi prefabricated solution

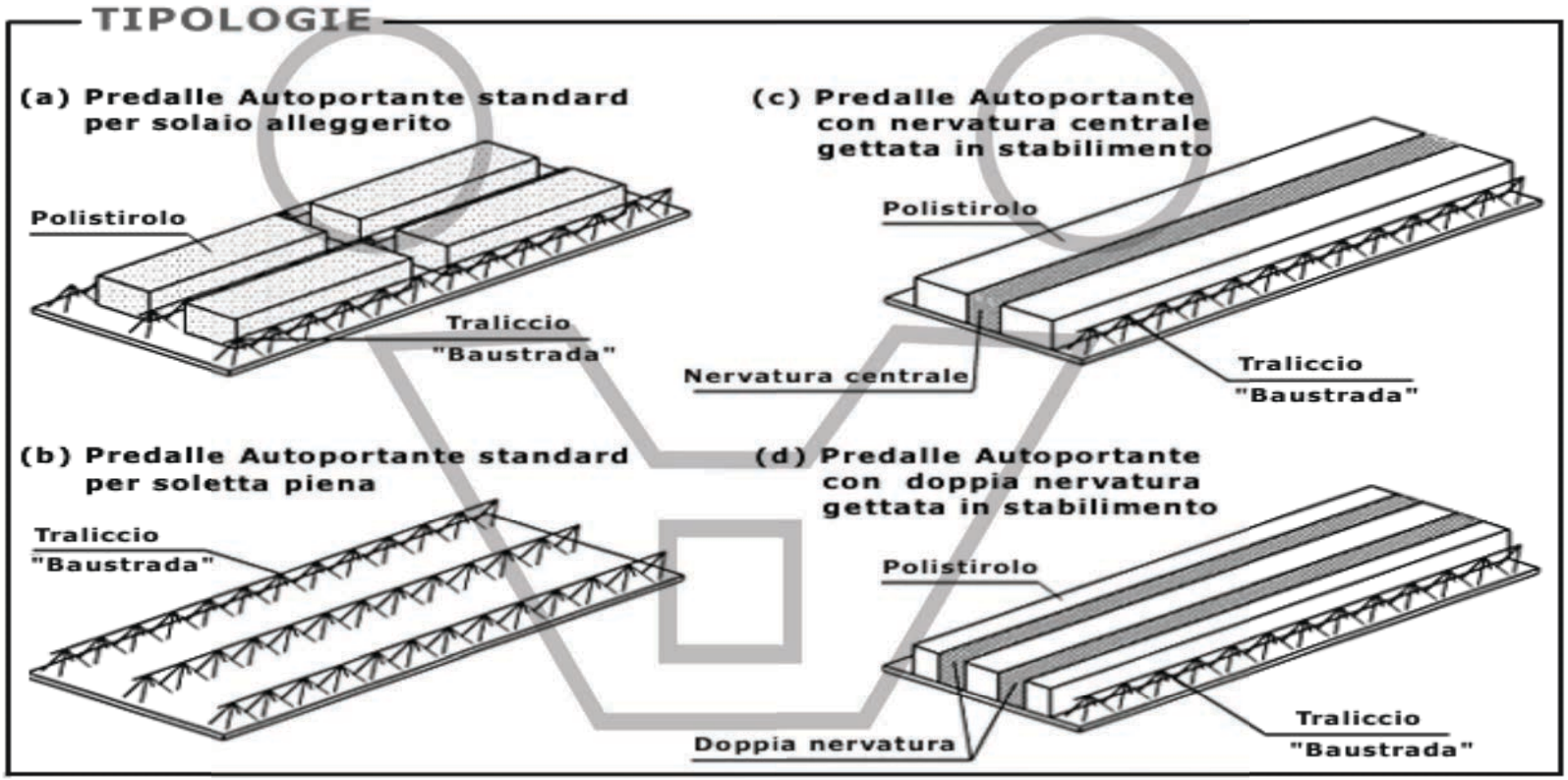
A **flat plate** is a one- or two-way system usually supported directly on columns or loadbearing walls It is one of the most common forms of construction of floors in buildings.

The principal feature of the flat plate floor is a uniform or near-uniform thickness with a flat soffit which requires only simple formwork and is easy to construct.

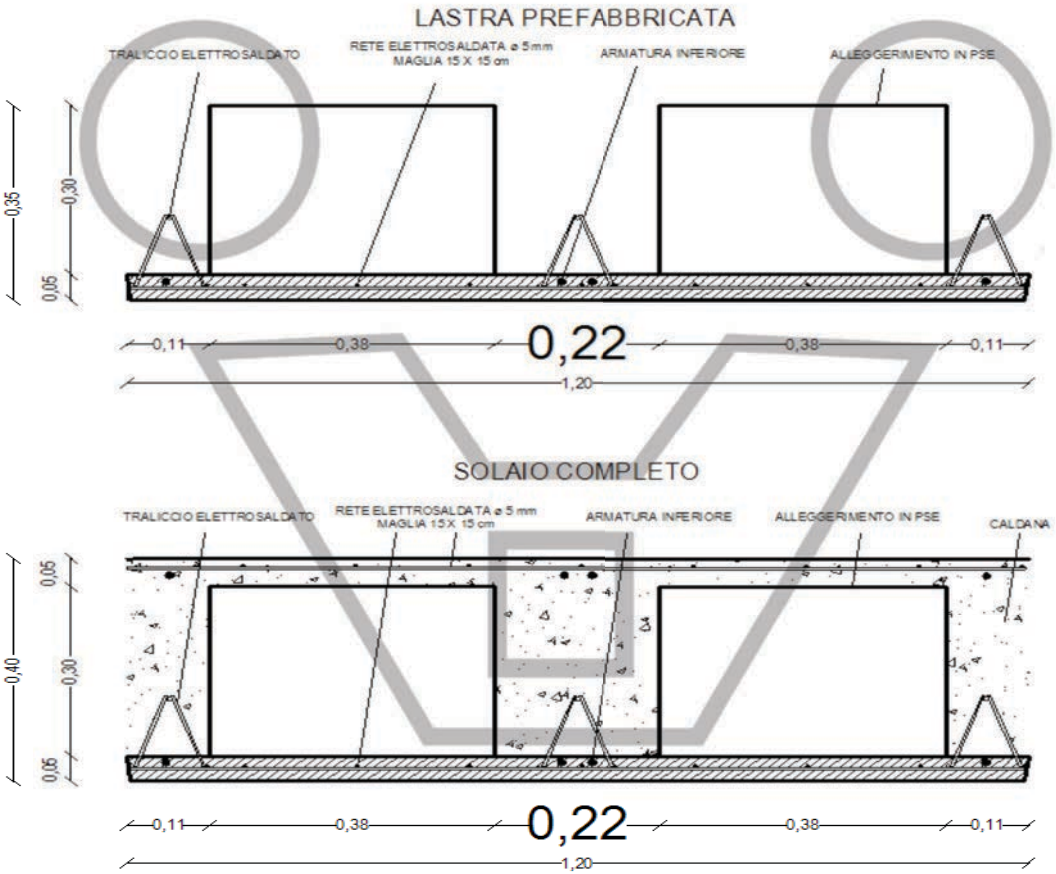
The floor allows great flexibility for locating horizontal services above a suspended ceiling or in a bulkhead.

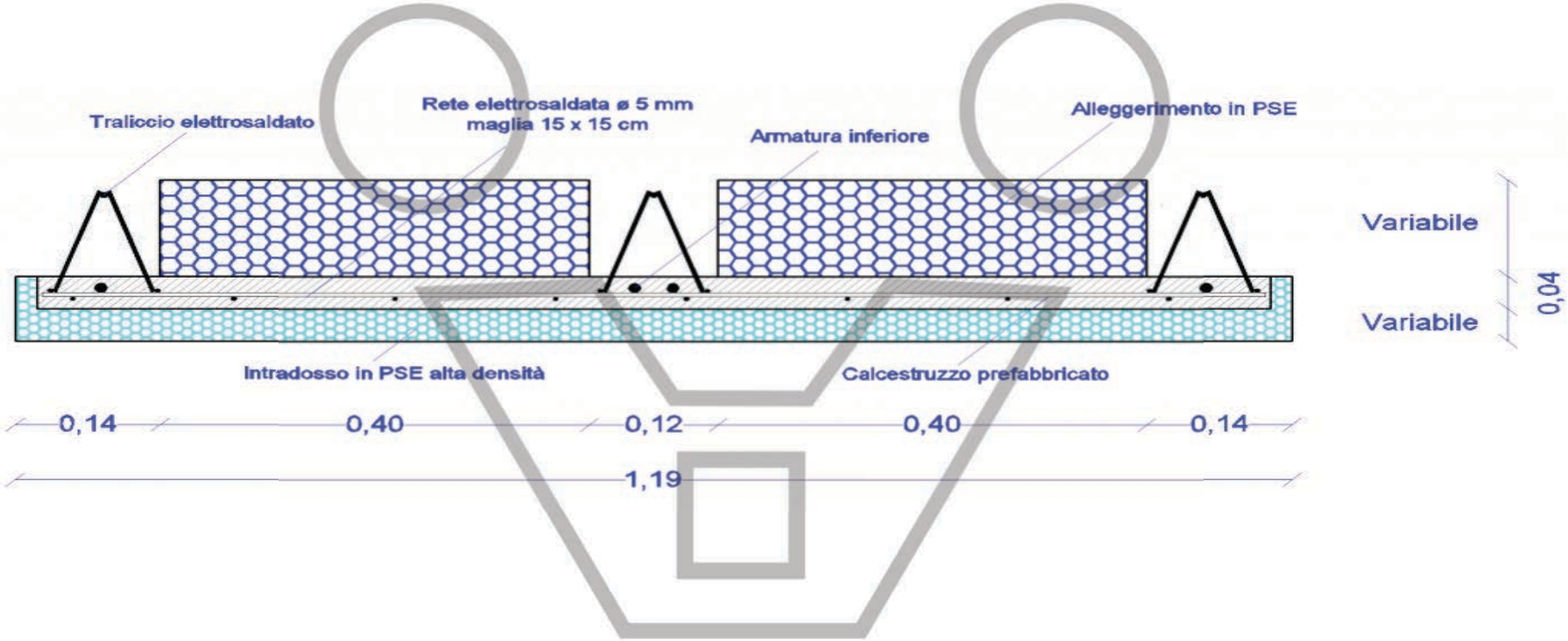


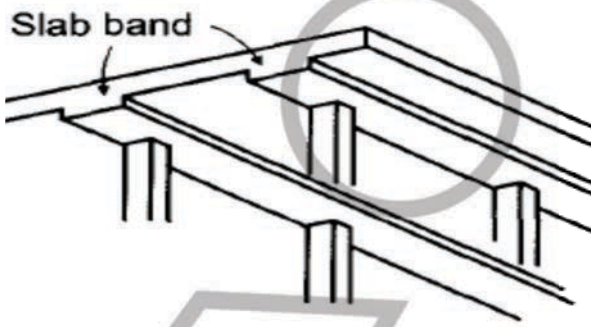



TIPOLOGIE
(a) Predalle Autoportante standard per solaio alleggerito
Polistirolo
Traliccio "Baustrada"
(c) Predalle Autoportante con nervatura centrale gettata in stabilimento
Polistirolo
Nervatura centrale
Traliccio "Baustrada"
(b) Predalle Autoportante standard per soletta piena
Traliccio "Baustrada"
(d) Predalle Autoportante con doppia nervatura gettata in stabilimento
Polistirolo
Doppia nervatura
Traliccio "Baustrada"

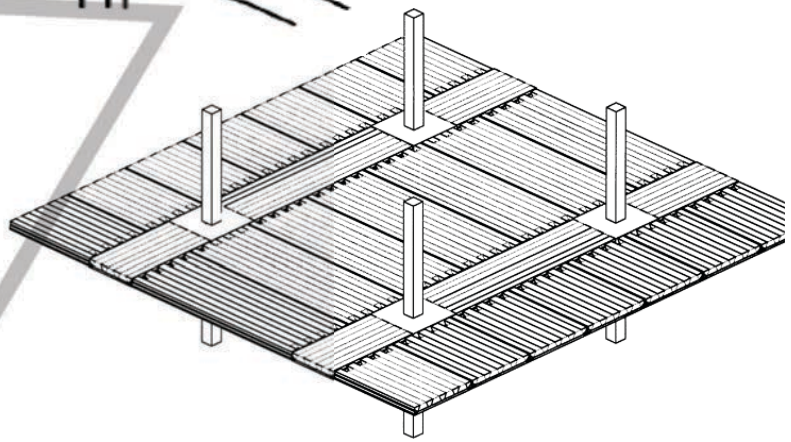
SOLAIO H 40 cm (5+30+5 cm)




Traliccio elettrosaldato
Rete elettrosaldata ø 5 mm
maglia 15 x 15 cm
Armatura inferiore
Alleggerimento in PSE
Variabile
Variabile
0,04
Intradosso in PSE alta densità
Calcestruzzo prefabbricato
0,14
0,40
0,12
0,40
0,14
1,19



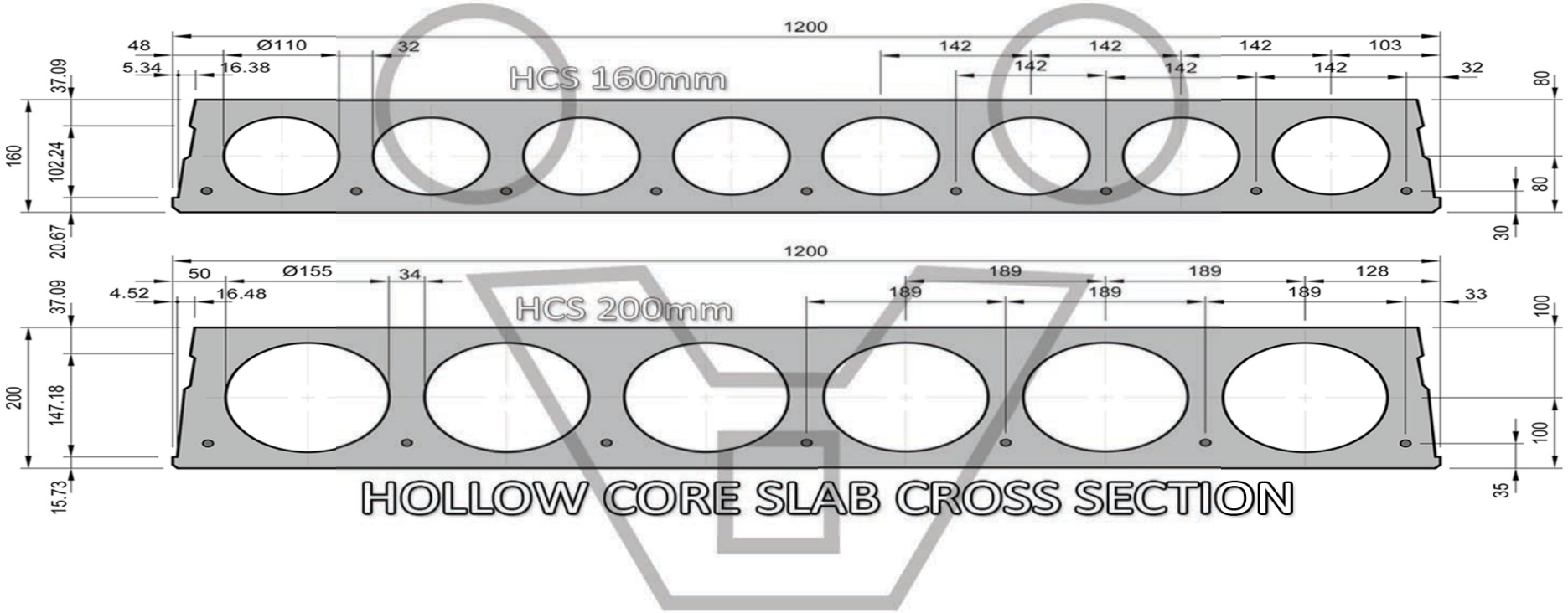
Vee Slabs

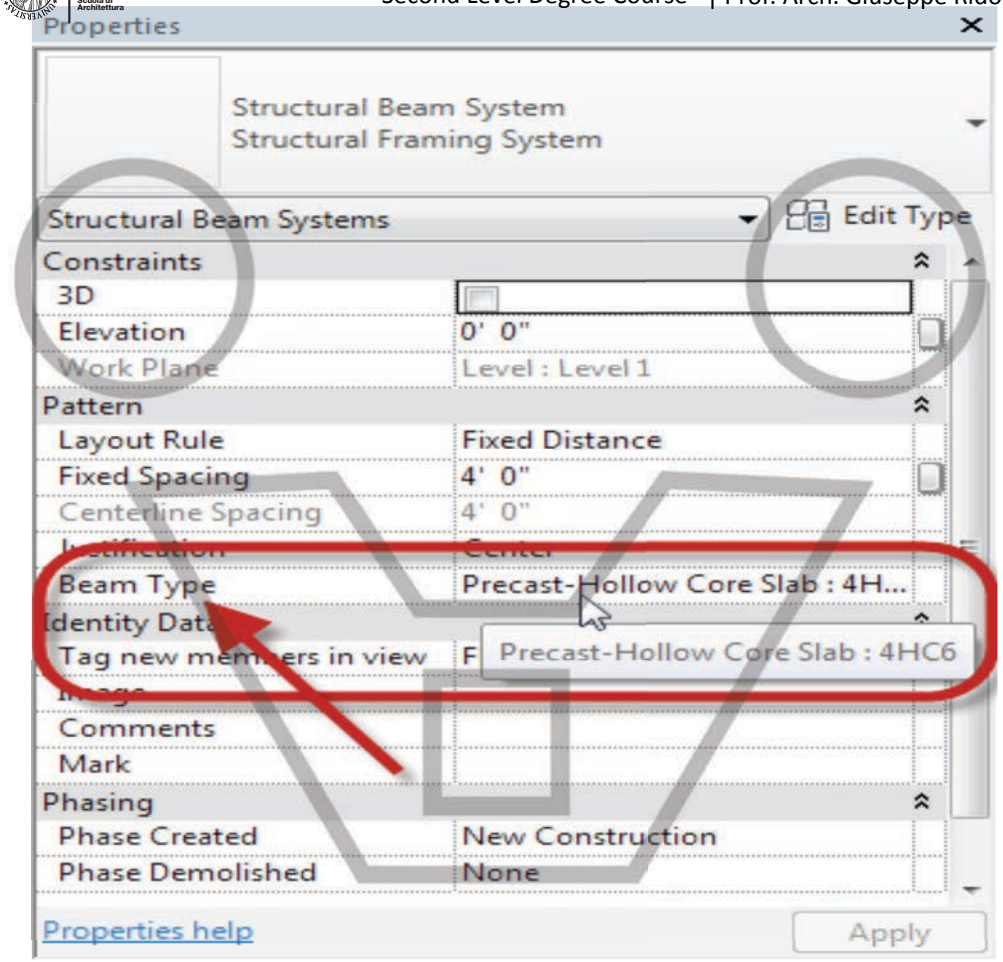


Band Beam and Slab

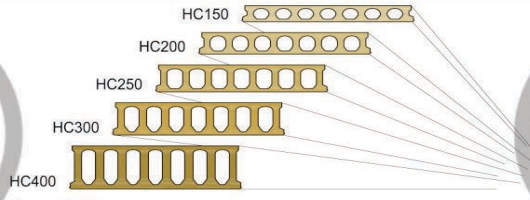
This system consists of a series of parallel, wide, shallow beams (known as band beams or thickened slab bands) with the floor slab spanning transversely between the bands.

The floor slab is designed as a continuous slab, with the shallow band beams carrying all loads from the slab. Band beams or thickened slab bands are a two-way slab system and are not treated as beams, except for shear.


HCS 160mm
1200
48
Ø110
32
142
142
142
103
5.34
16.38
142
142
142
32
37.09
160
102.24
20.67
80
80
30
HCS 200mm
1200
50
Ø155
34
189
189
128
4.52
16.48
189
189
189
33
37.09
200
147.18
15.73
100
100
35
HOLLOW CORE SLAB CROSS SECTION


Properties
Structural Beam System
Structural Framing System
Structural Beam Systems
Edit Type
Constraints
3D
Elevation
0' 0"
Work Plane
Level : Level 1
Pattern
Layout Rule
Fixed Distance
Fixed Spacing
4' 0"
Centerline Spacing
4' 0"
Beam Type
Precast-Hollow Core Slab : 4H...
Precast-Hollow Core Slab : 4HC6
Comments
Mark
Phasing
Phase Created
New Construction
Phase Demolished
None
Properties help
Apply

Precast Hollowcore Slab



Hollowcore Load Spans

Unfactored Live Load (kn/sqm) - including self weight and screed

CLEAR SPAN (m) ⇨	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5
HC-150																														
Without structural screed	48.1	36.5	27.5	20.2	15.1	11.5	9.0	7.1	5.7	4.5	3.6	2.9	2.4	1.8	1.4	1.1	0.8													
With 75mm structural screed	46.3	35.8	28.9	24.0	20.5	17.3	13.5	9.8	7.1	5.0	3.3	1.9	0.8																	
75mm Structural screed + Temporary propping	46.3	35.8	28.9	24.0	20.5	17.7	14.6	11.5	9.1	7.3	5.8	4.4	3.2	2.3	1.4	1.1	0.8													
HC-200																														
Without structural screed			42.4	35.6	30.6	25.5	20.3	16.4	13.4	11.1	9.3	7.8	6.5	5.5	4.7	3.9	3.3	2.8	2.3											
With 75mm structural screed			40.9	34.0	29.0	25.2	22.1	19.6	17.6	15.4	12.4	9.9	7.9	6.2	4.8	3.6	2.6	1.8	0.9											
75mm Structural screed + Temporary propping			40.9	34.0	29.0	25.2	22.1	19.6	17.6	15.9	13.8	11.4	9.3	7.7	6.2	5.1	4.0	3.1	2.4											
HC-250																														
Without structural screed							31.0	25.2	20.8	17.4	14.6	12.4	10.6	9.1	7.8	6.8	5.8	5.0	4.4	3.7	3.2									
With 75mm structural screed							30.4	27.0	24.3	22.0	19.5	16.1	13.4	11.1	9.2	7.6	6.2	5.0	3.9	3.0	2.2	1.5	0.9							
75mm Structural screed + Temporary propping							30.4	27.0	24.3	22.0	19.8	17.3	14.5	12.2	10.3	8.7	7.3	6.1	5.1	4.1	3.3	2.6	2.0							
HC-300																														
Without structural screed											23.0	19.6	16.8	14.5	12.3	10.7	9.3	8.2	7.2	6.3	5.5	4.8	4.2	3.6						
With 75mm structural screed											27.4	24.2	21.6	18.6	15.3	13.0	11.0	9.3	7.8	6.6	5.4	4.4	3.5	2.7	2.0	1.4	1.8			
75mm Structural screed + Temporary propping											27.4	24.2	21.6	19.4	16.3	14.0	12.0	10.3	8.8	7.6	6.4	5.4	4.5	3.7	3.0	2.4	1.8			
HC-400																														
Without structural screed															19.3	16.8	14.7	12.9	11.4	10.0	8.8	7.7	6.8	6.0	5.2	4.5				
With 75mm structural screed															22.7	20.5	17.7	15.2	13.1	11.2	9.6	8.2	6.9	5.7	4.7	3.8	3.0	2.2	1.5	0.9
75mm Structural screed + Temporary propping															22.7	20.5	18.0	15.8	13.8	12.0	10.4	9.0	7.7	6.5	5.5	4.6	3.8	3.0	2.3	1.7

Note:	Self Weight (Incl. screed)	Reinforcement	Cores
HC-150	2.23 kn/sqm + 1.8 kn/sqm screed	8 nos. 9.3mm diameter strands	7 nos. 110mm wide cores
HC-200	2.74 kn/sqm + 1.8 kn/sqm screed	6 nos. 12.5mm + 2 nos. 9.3mm diameter strands	7 nos. 110mm wide cores
HC-250	3.10 kn/sqm + 1.8 kn/sqm screed	6 nos. 12.5mm + 4 nos. 9.3mm diameter strands	7 nos. 109mm wide cores
HC-300	3.80 kn/sqm + 1.8 kn/sqm screed	8 nos. 12.5mm + 4 nos. 9.3mm diameter strands	7 nos. 103mm wide cores
HC-400	4.92 kn/sqm + 1.8 kn/sqm screed	8 nos. 12.5mm + 4 nos. 9.3mm diameter strands and 2 nos. 9.3mm diameter top strands	7 nos. 97mm wide cores

CONCAST
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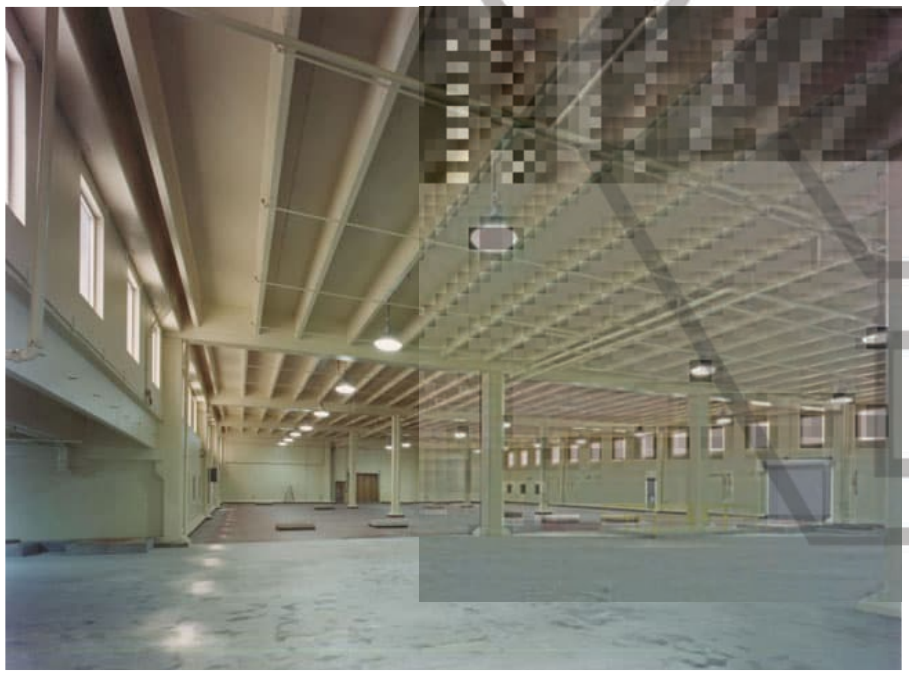
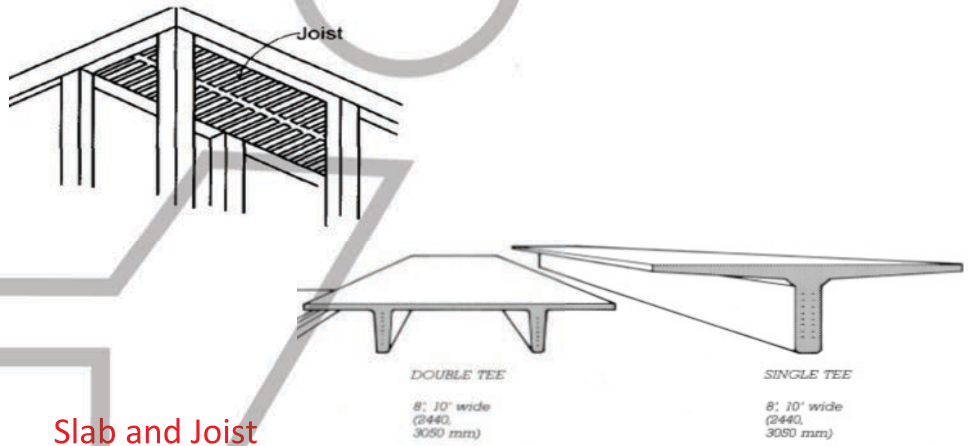
Precast Hollowcore Slab



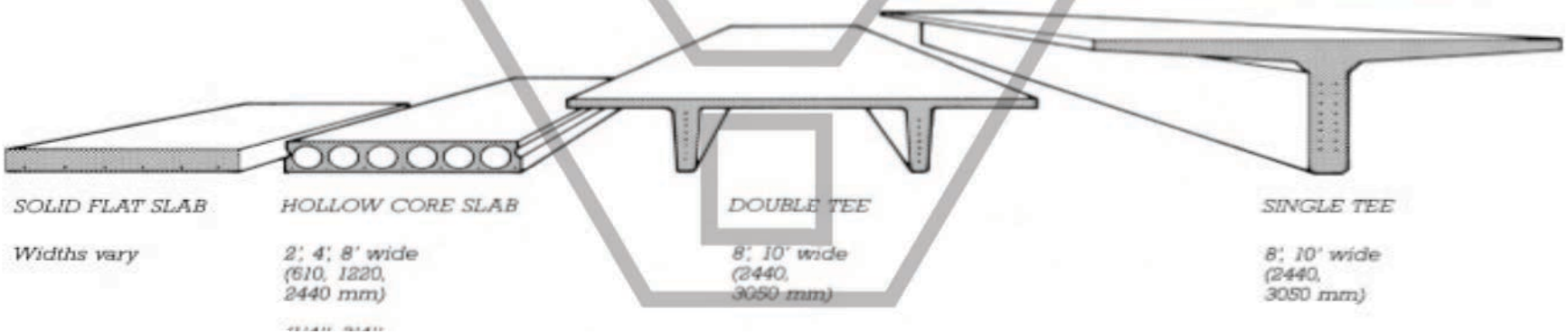


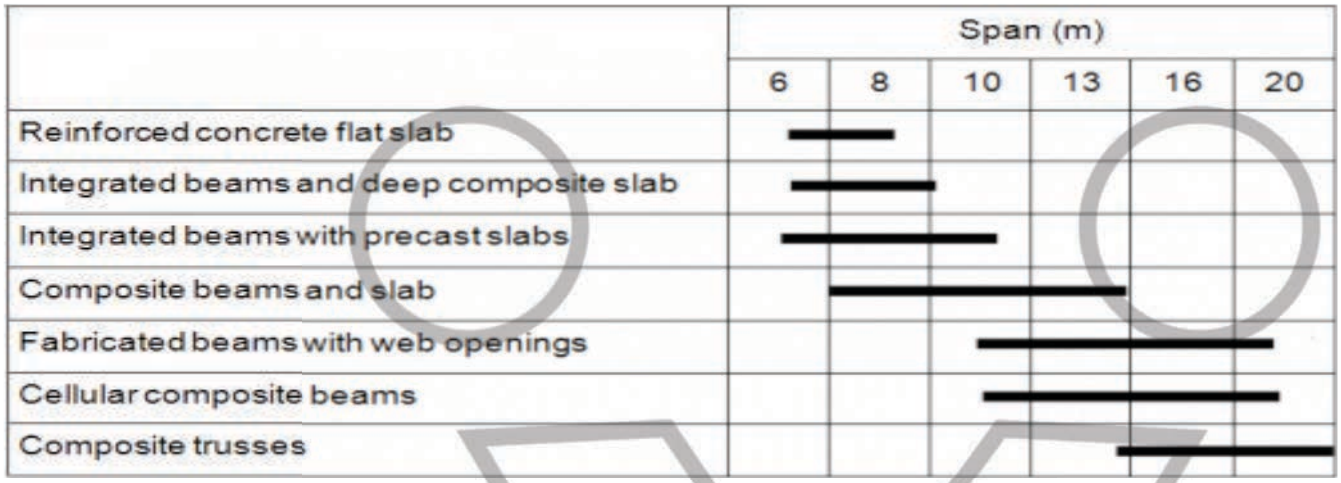
Slab and Joist

This system consists of a slab spanning between beams (which span between columns) and usually an intermediate joist in one direction.

Frequently, the slab thickness between the joists is controlled by requirements for fire-resistance.

- Used for floor and roof decks.
- Deeper elements (toward the right below) span further than those that are shallower (toward the left).
- Right: Hollow core slabs stacked at the precasting plant.





Span to depth ratios for different steel beam solutions

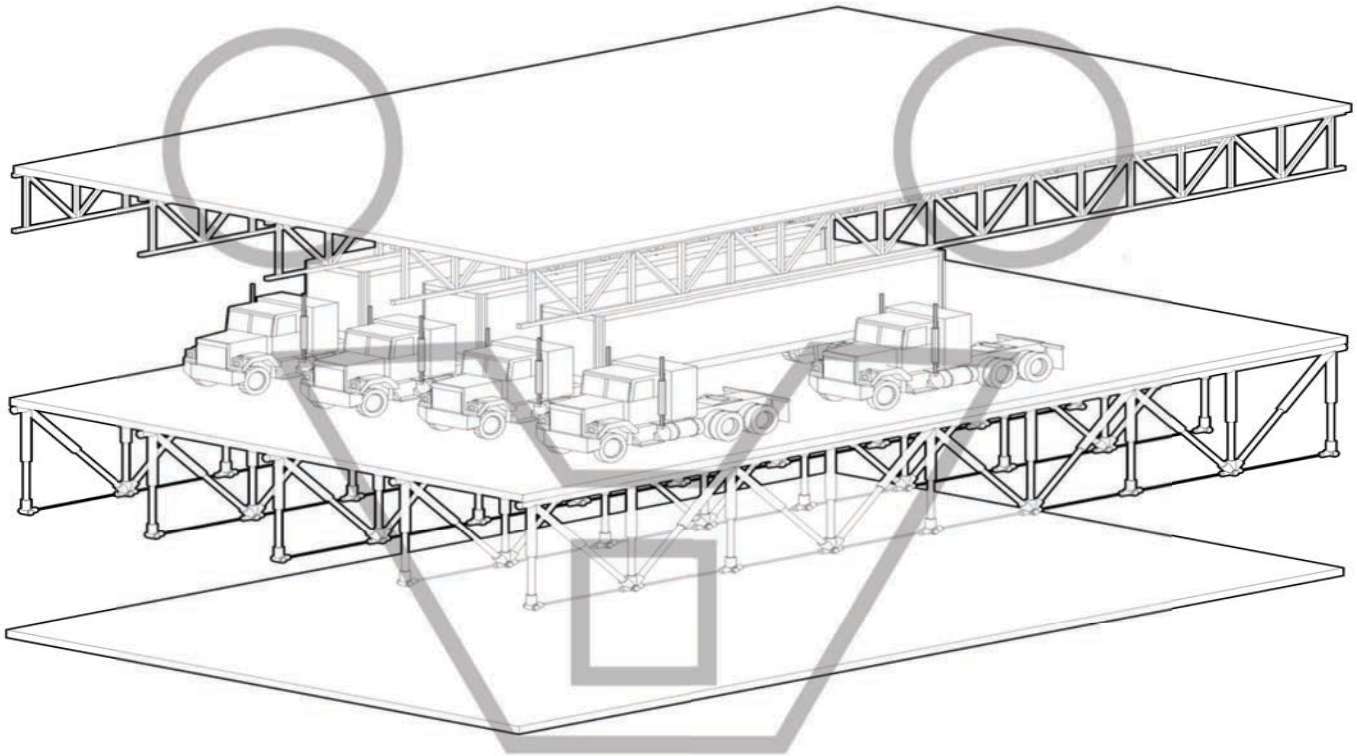
Non-composite primary beams Floor = span/20 Roof = span/25

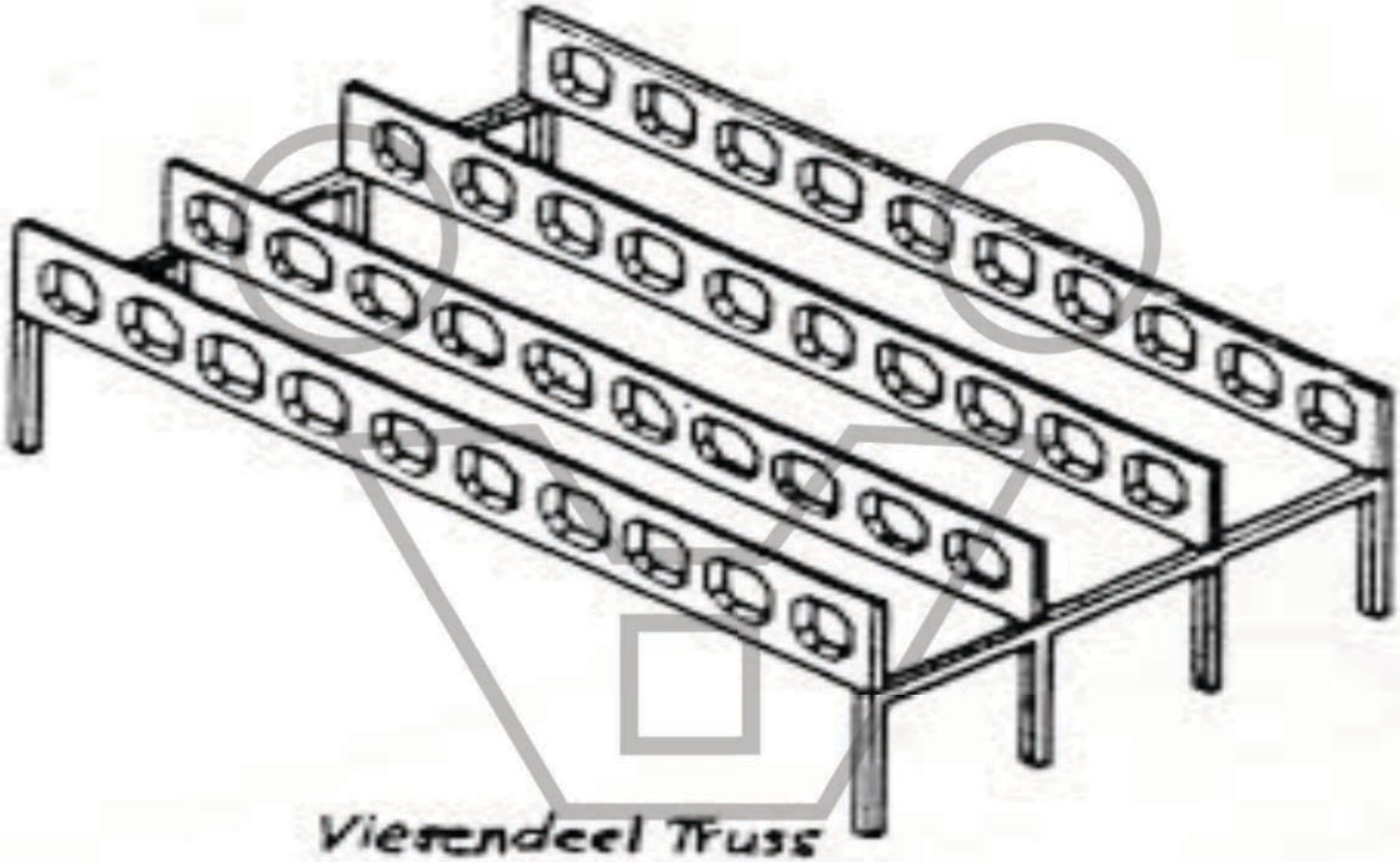
Non-composite secondary beams Floor = span/25 Roof = span/30

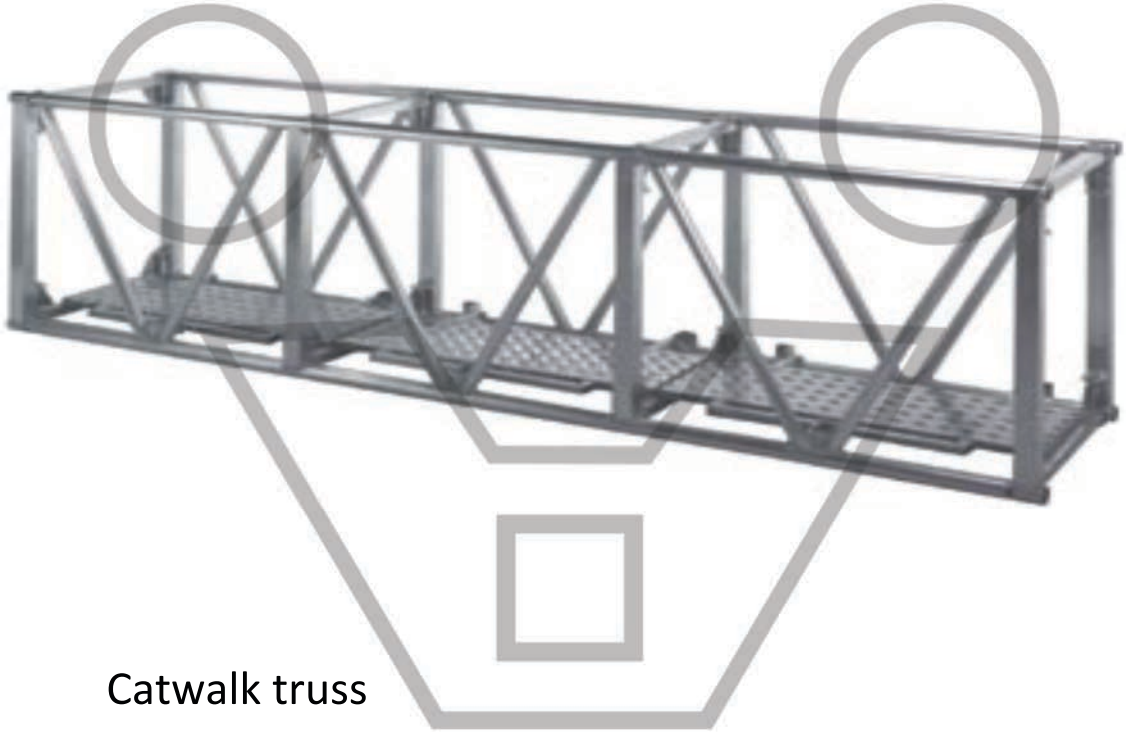
Composite beams Span/16 to span/18 (note depth is steel beam plus slab)

Long span solutions tend to be shallower, up to span/20

VIERENDEL, SPATIAL and CELLULAR TRUSS



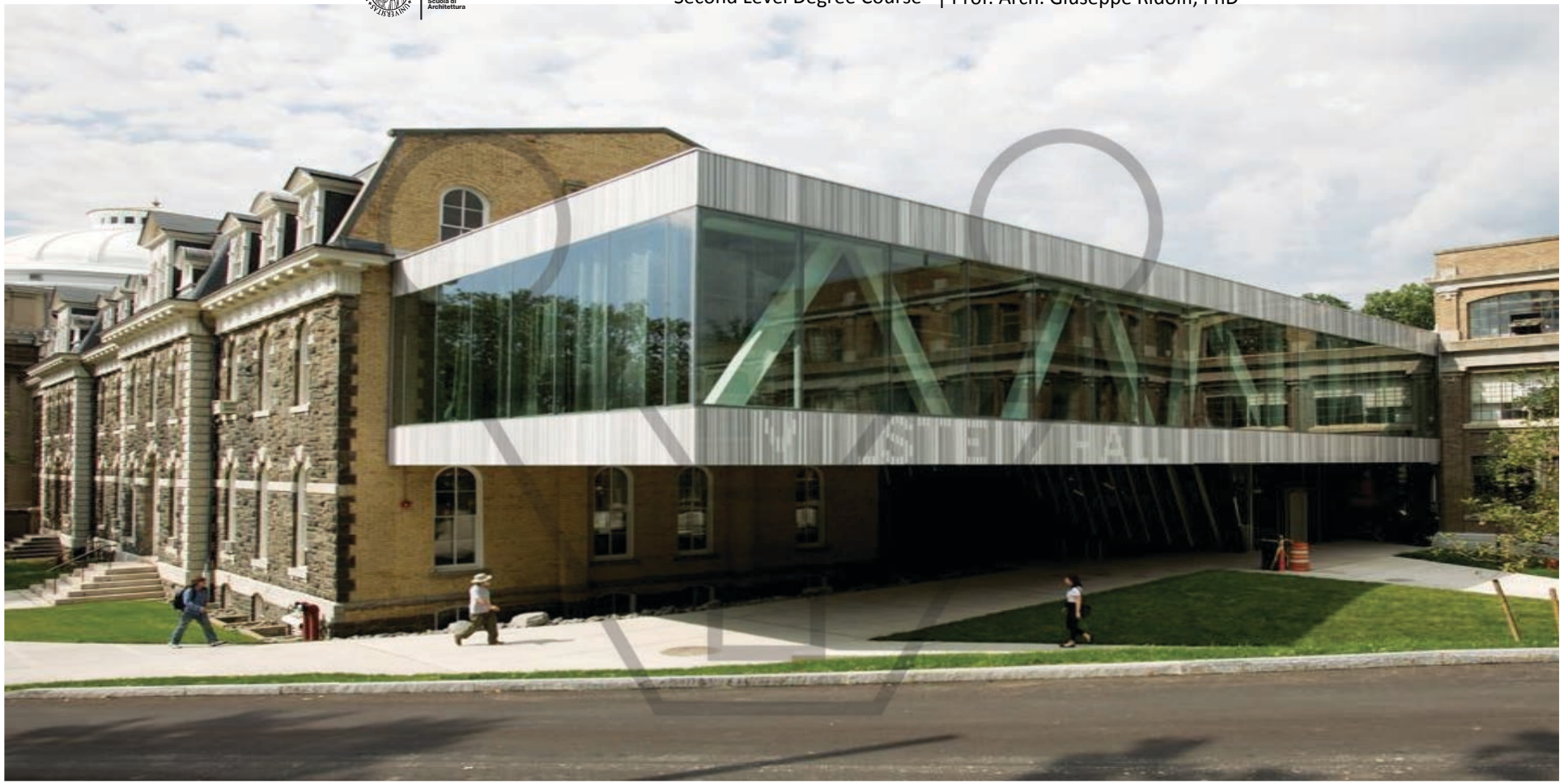

Vierendeel Truss



Catwalk truss

Parapet BEAM

Single tee slabs



Milstein Hall, designed by OMA.