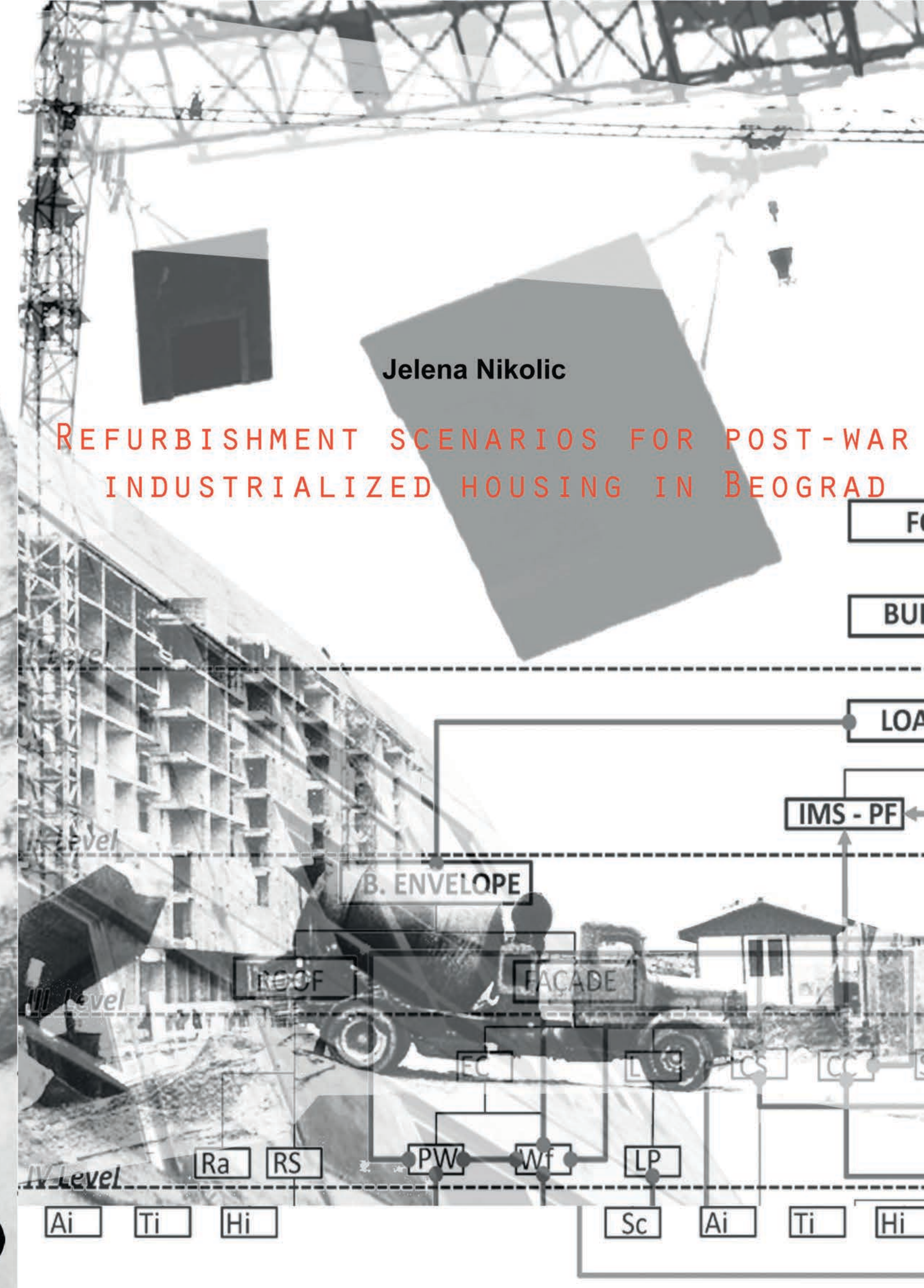
Jelena Nikolic

Refurbishment scenarios for post-war industrialized housing in Beograd



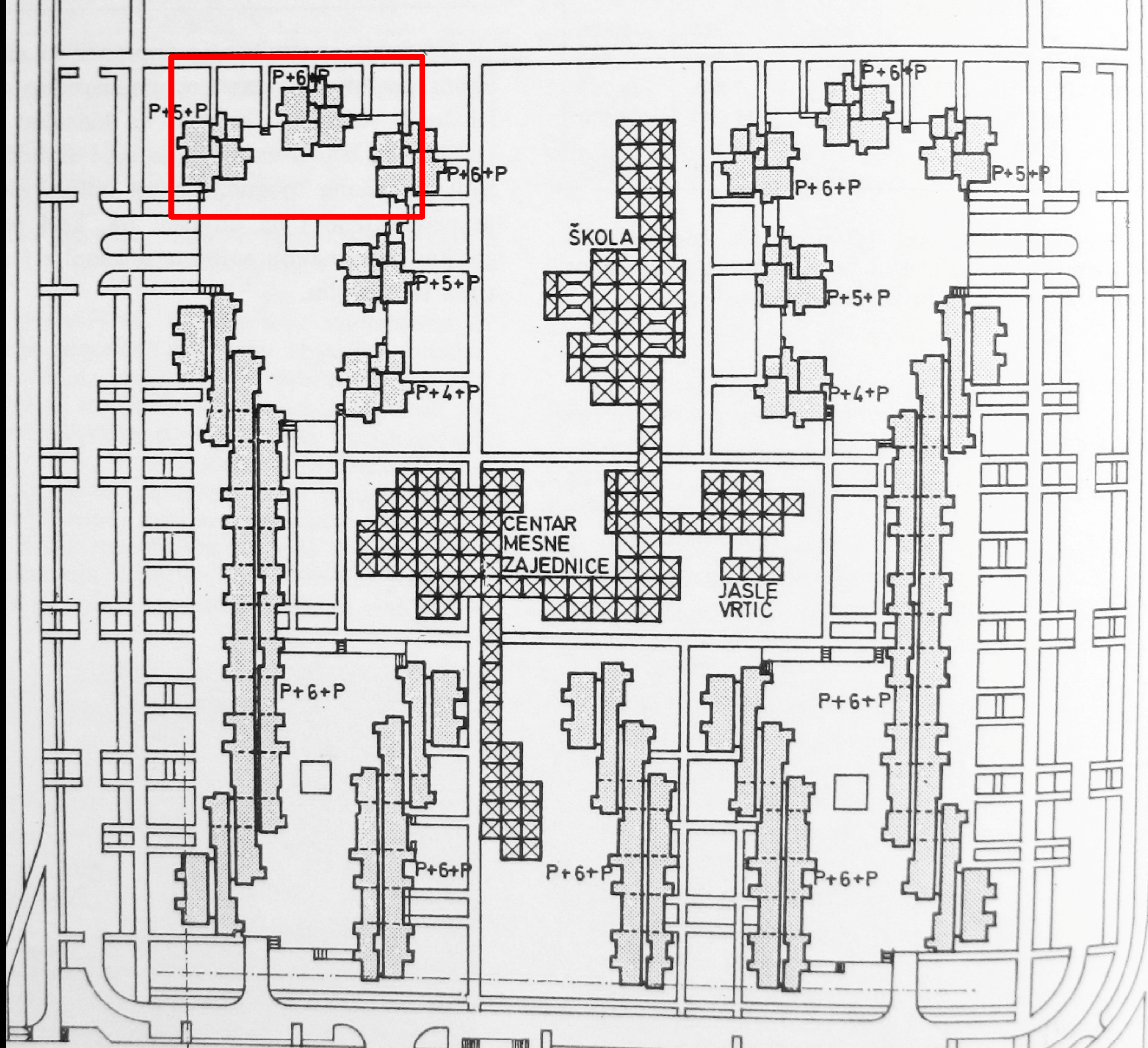
Refurbishment scenarios for post-war industrialized housing in Beograd

PhD Thesis 2015

UPC

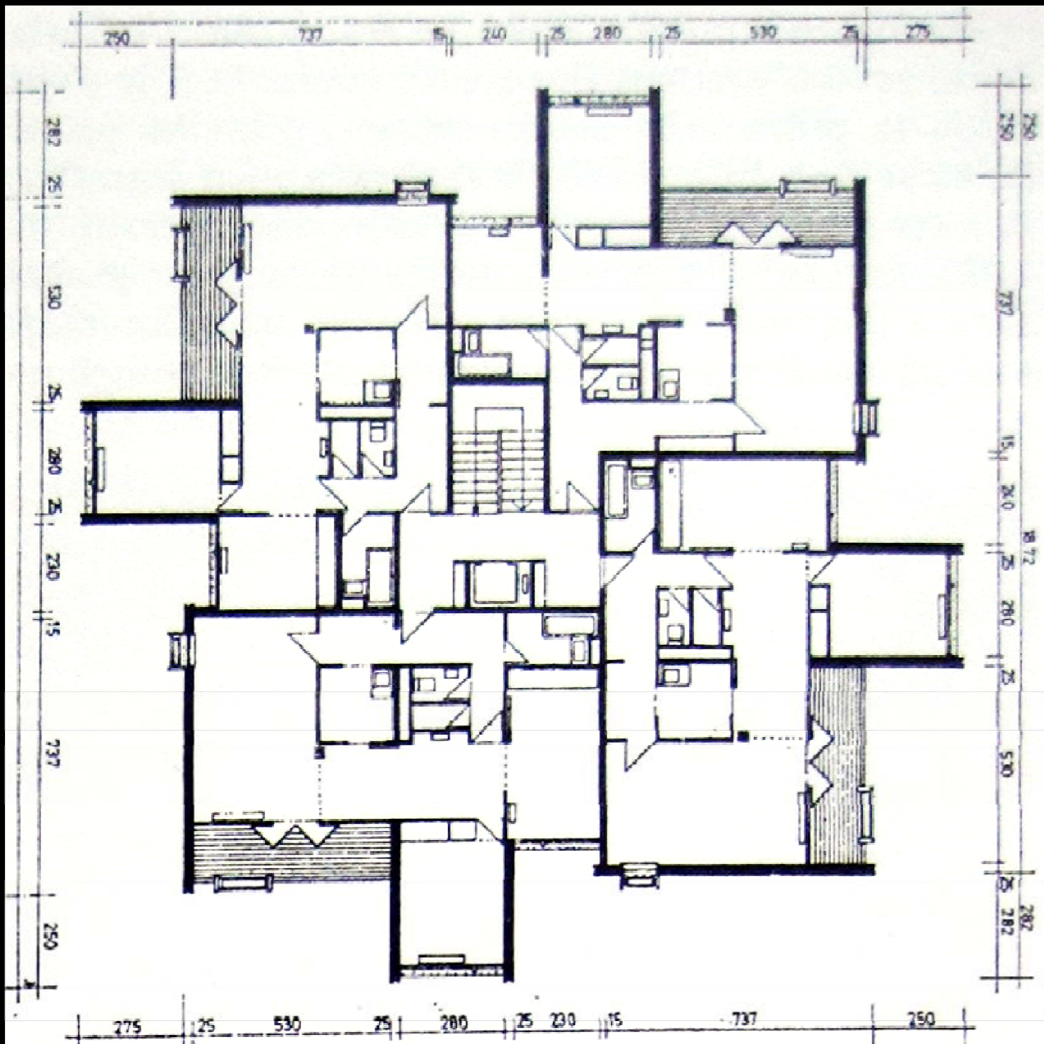
APPENDIX - **Block No. 22: Tower Building**

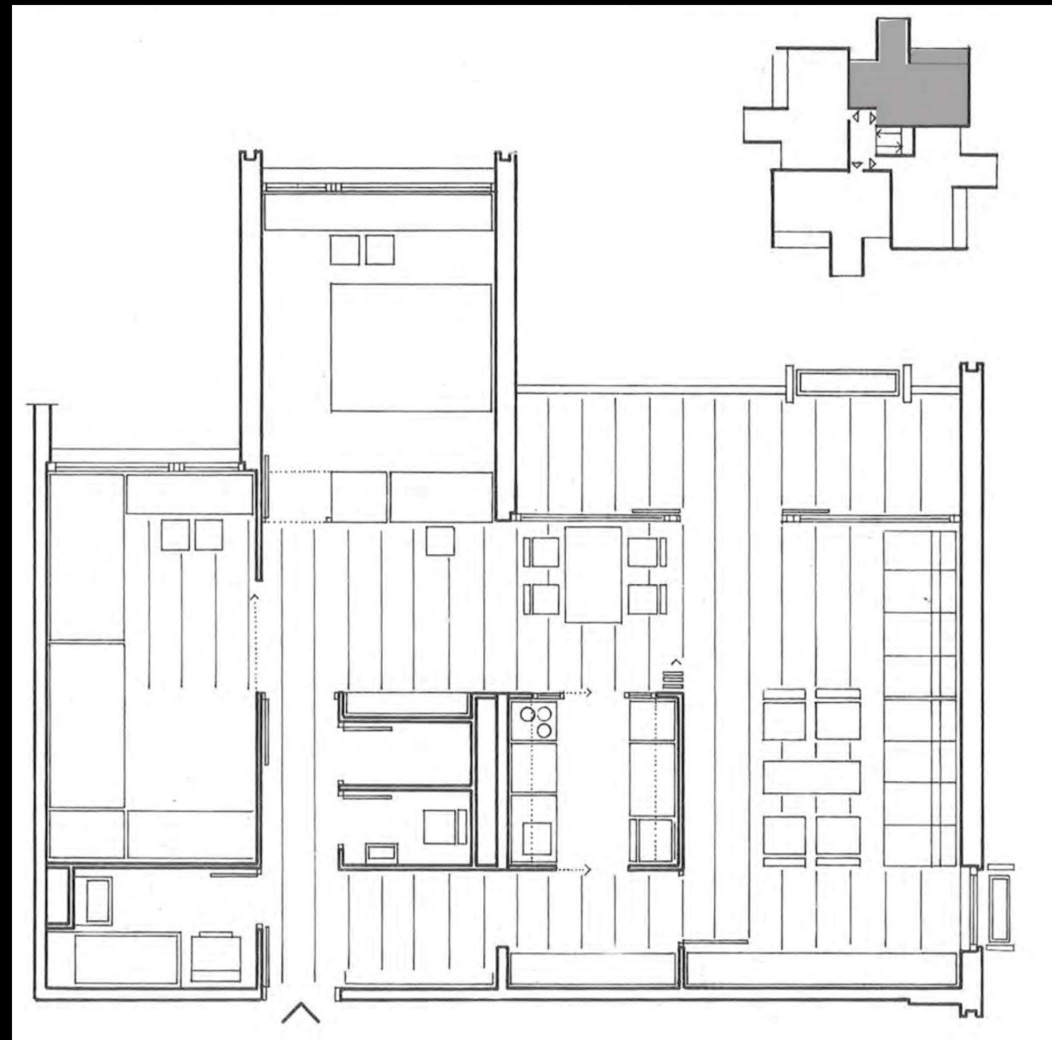
Block No. 22:



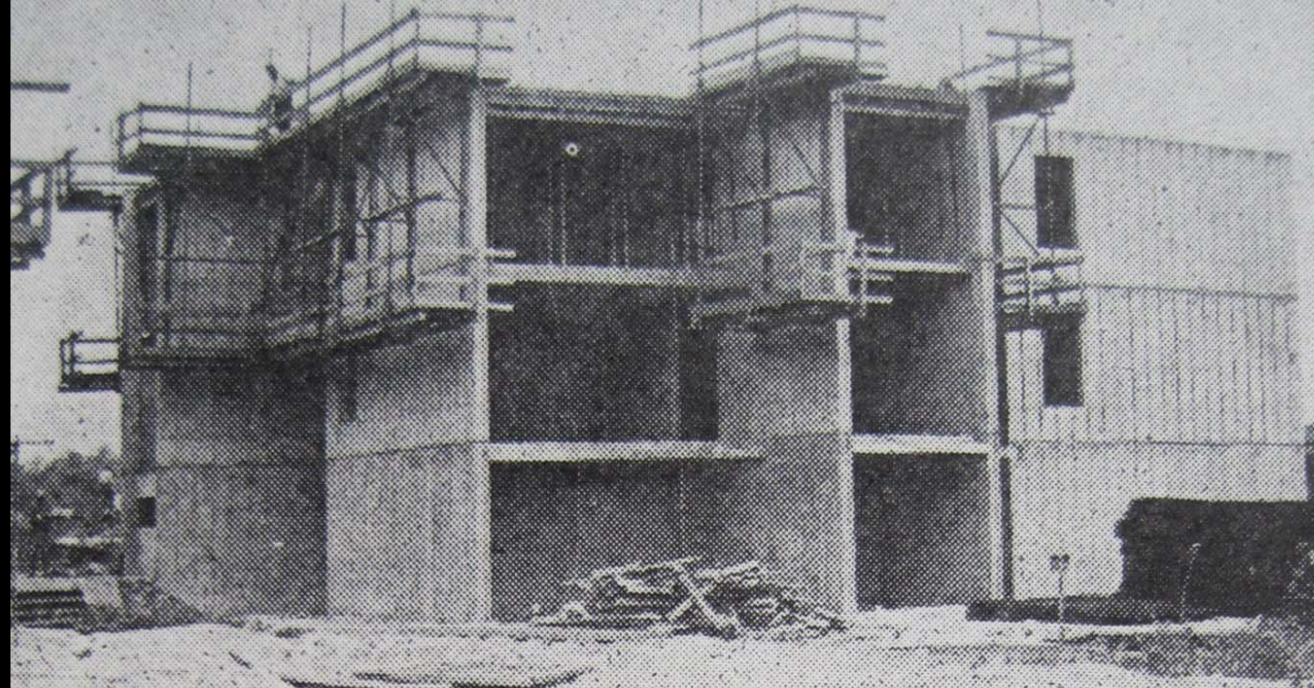
Djokovic, M. (1978). "Izgradnja stambenog bloka 22 u Novom Beogradu" / *Building of the Block No.22 in New Belgarde*, *Izgradnja, br.12*, 8–15.

Block No. 22: Tower building and the dwelling layout

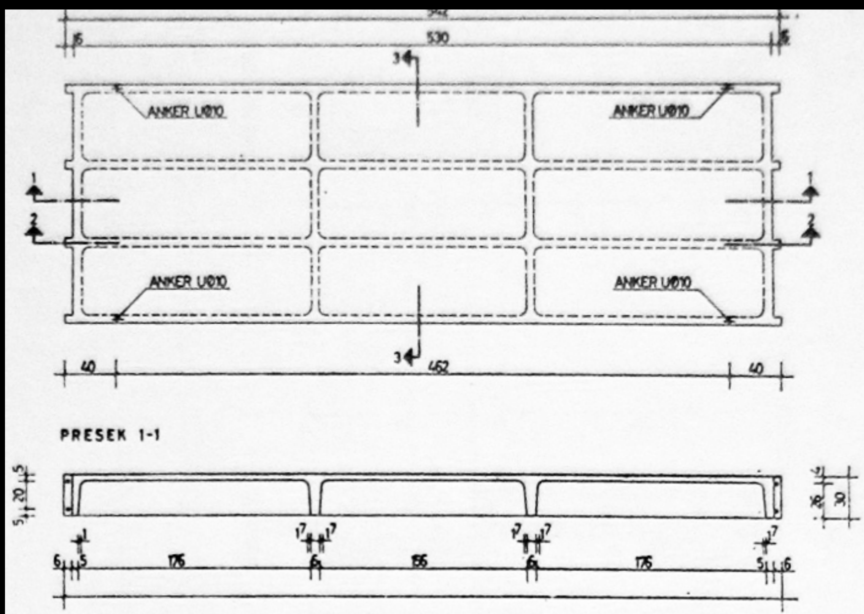


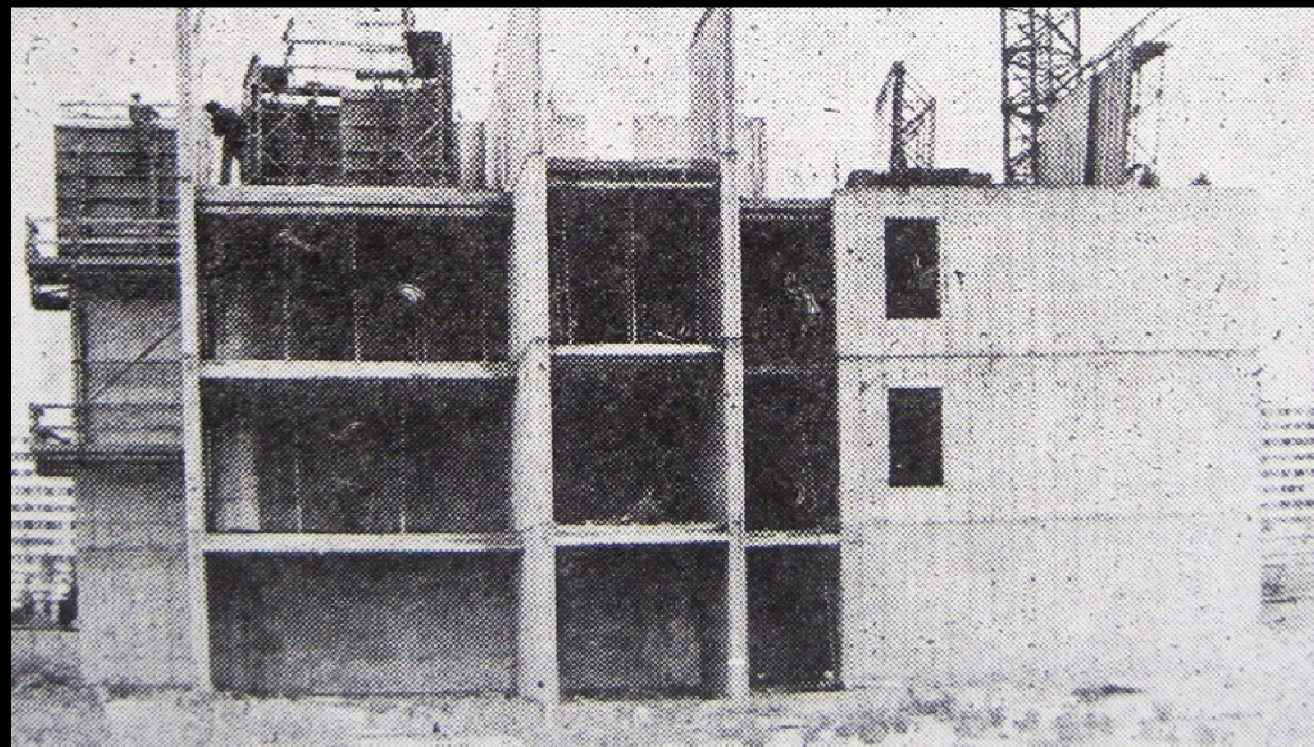


Djokovic, M. (1978). “Izgradnja stambenog bloka 22 u Novom Beogradu” / *Building of the Block No.22 in New Belgarde*, *Izgradnja, br.12*, 8–15.

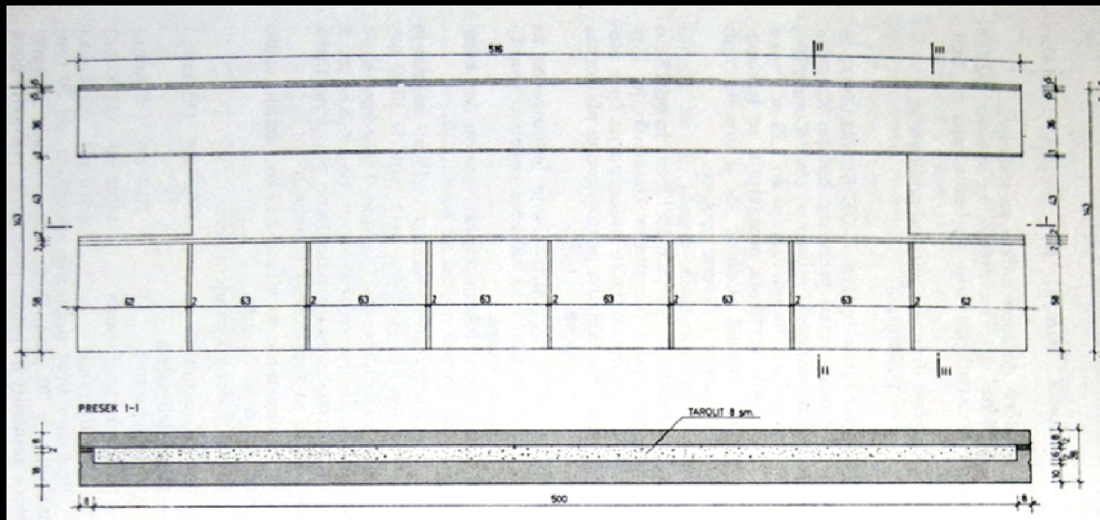


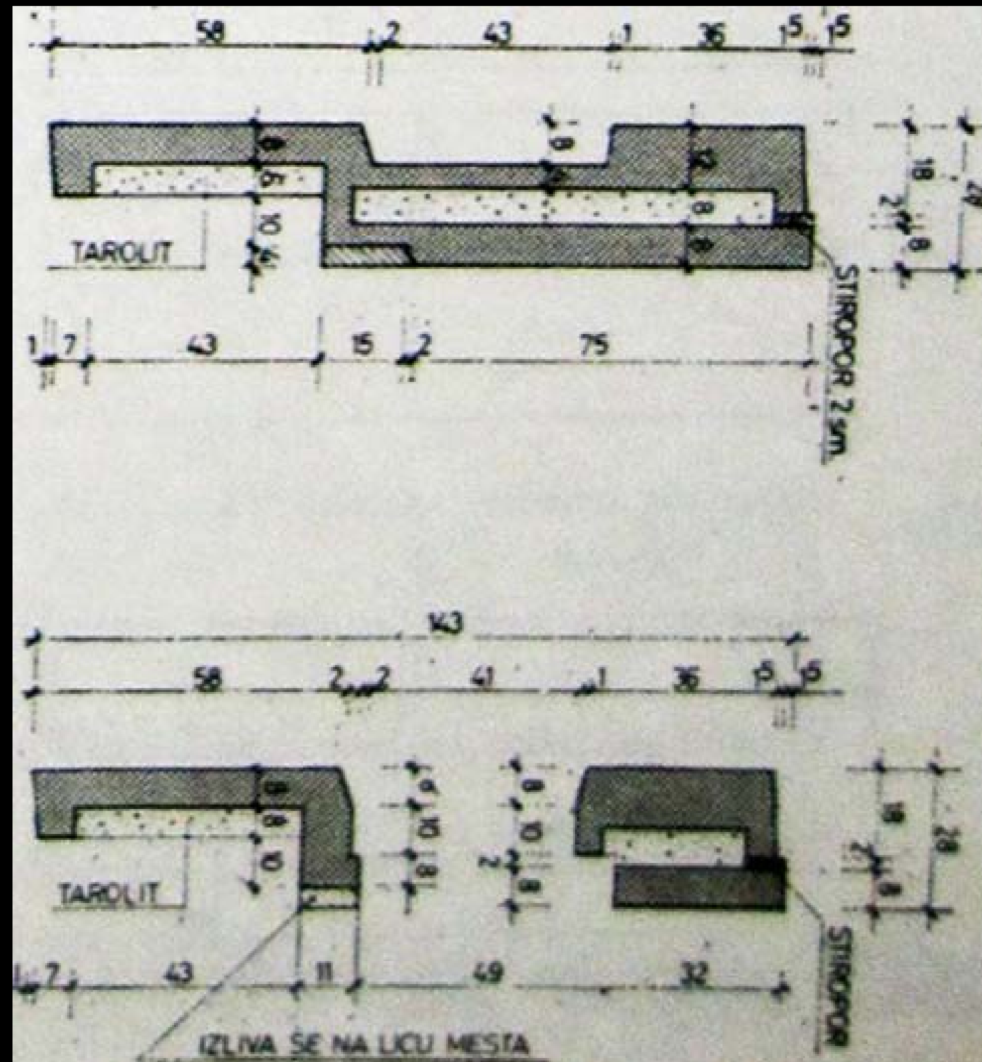
Mixed Building Model _***Conventional cross-bearing wall system and precast slab with ribs***





Djokovic, M. (1978). "Izgradnja stambenog bloka 22 u Novom Beogradu" / *Building of the Block No.22 in New Belgarde*, *Izgradnja, br.12*, 8–15.

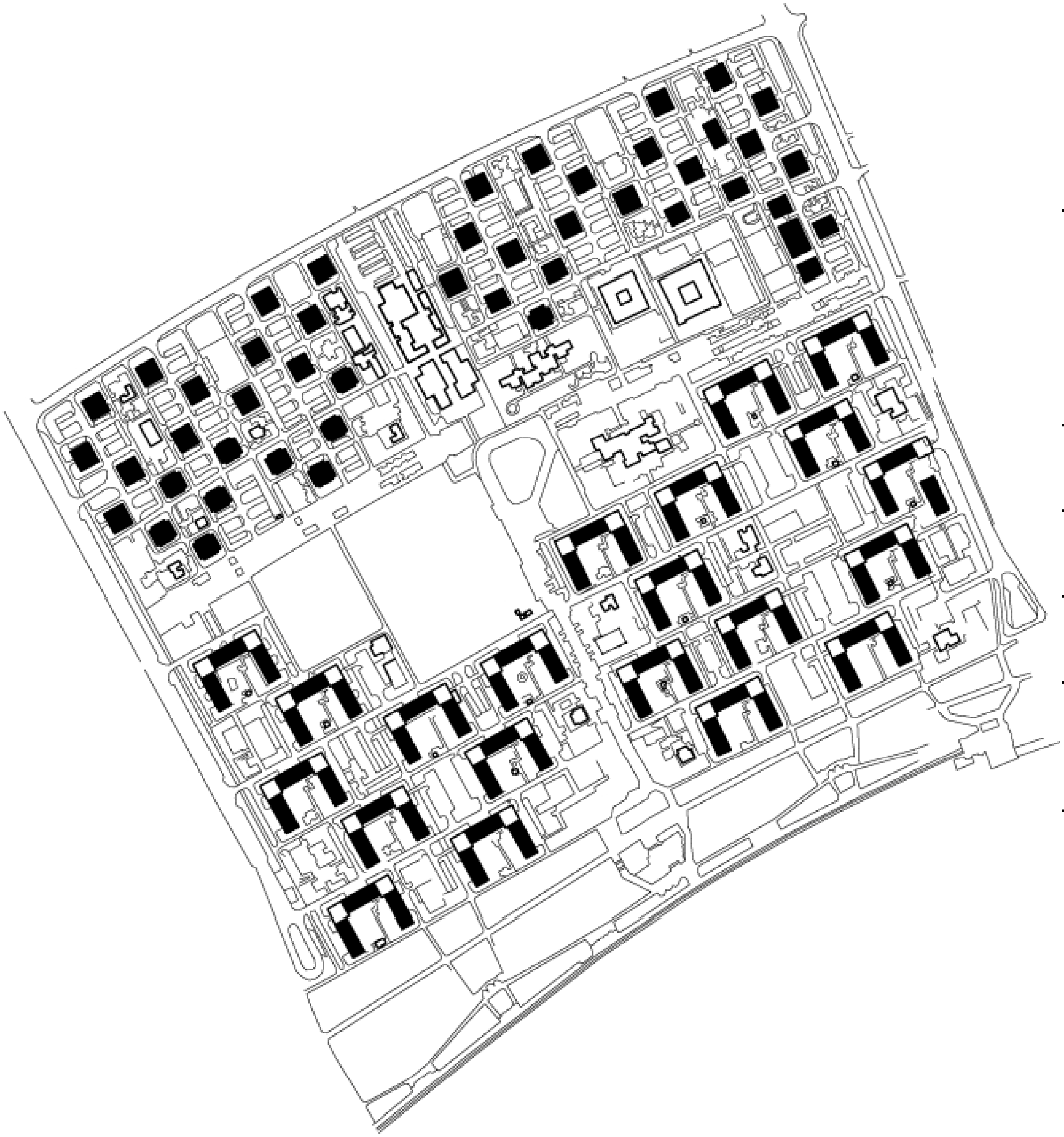




Prefabricated façade panel

Djokovic, M. (1978). “Izgradnja stambenog bloka 22 u Novom Beogradu” / *Building of the Block No.22 in New Belgarde*, *Izgradnja, br.12*, 8–15.

APPENDIX - **Block No. 45: Atrium Building**



Block No. 45: Atrium Building

URBAN DESIGN
Ivan Tepe!, Velimir Gradelj, Milutin Glavički,
Jovan Mi!ković (Institute of Urbanism Belgrade)

ARCHITECTURAL DESIGN
Mihajlo Čanak (17 stories),
Grgur Popović (13, 15 stories),
Risto Sekerinski (demi-atrium, 2&3 stories)
Branko Aleksić (7 stories)

INVESTOR
Agency for the construction of Belgrade

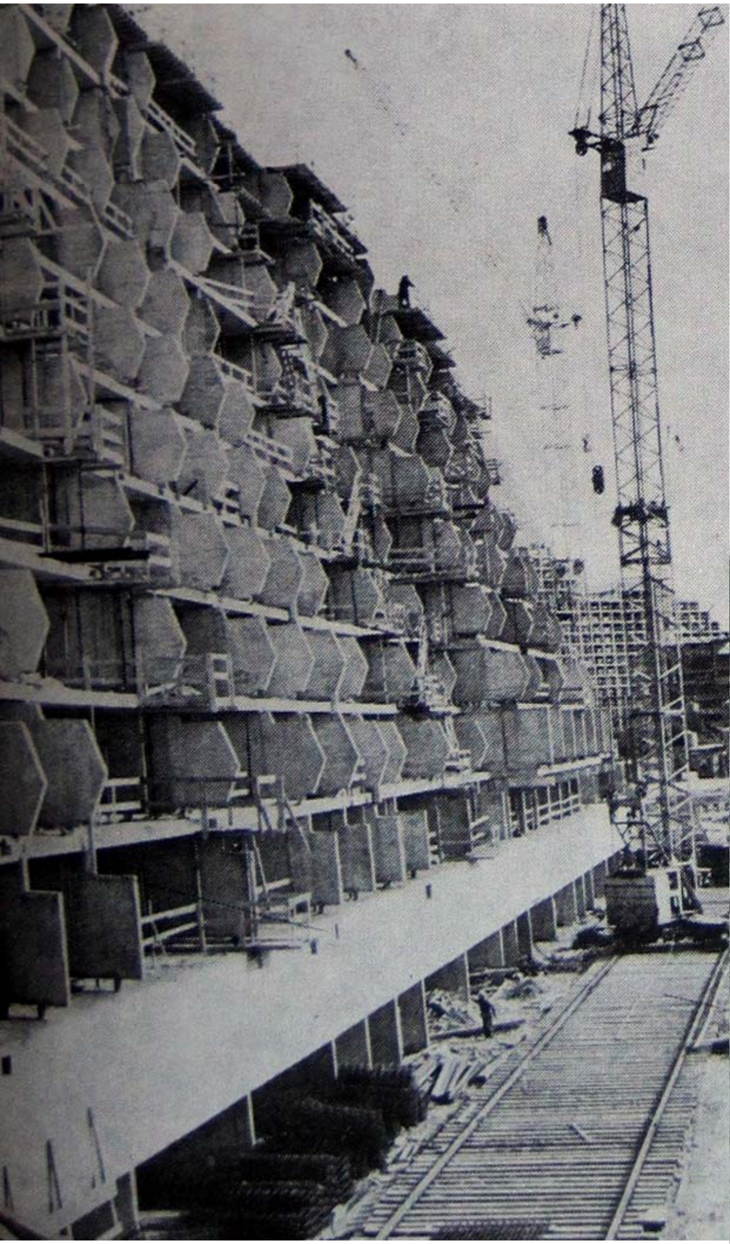
USER
City Housing Company of Belgrade

Developed by INPROS
4800 built apartments

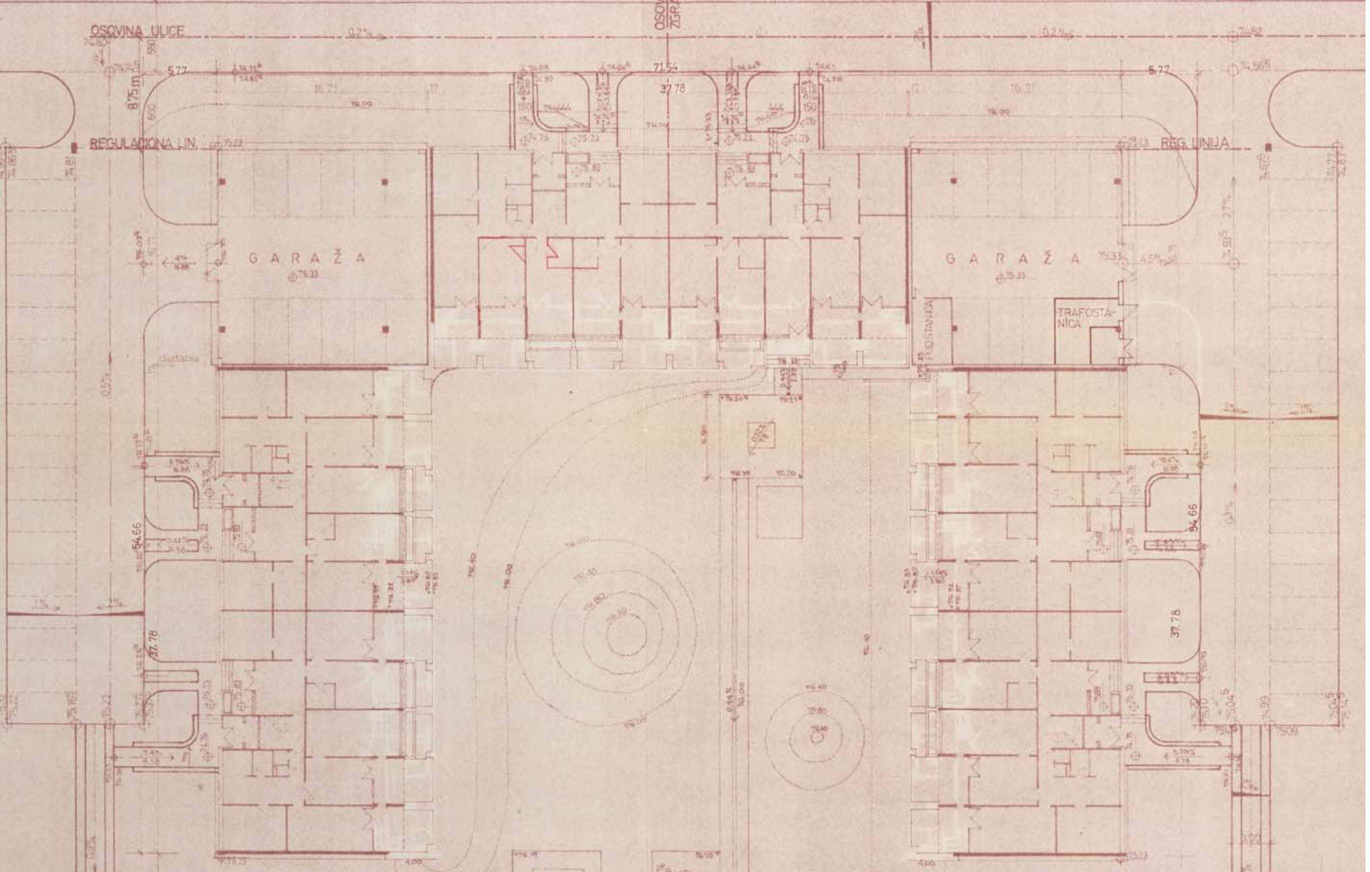
ADDITIONAL SERVICES
elementary school, kindergarten, community center,
artisan center, supermarkets, garages

Block 45: 1965

Apartment example: semi-atrium - three lamellas, tower buildings



Block No. 45_Atrium building _ Trudbenim panel system: construction in progress



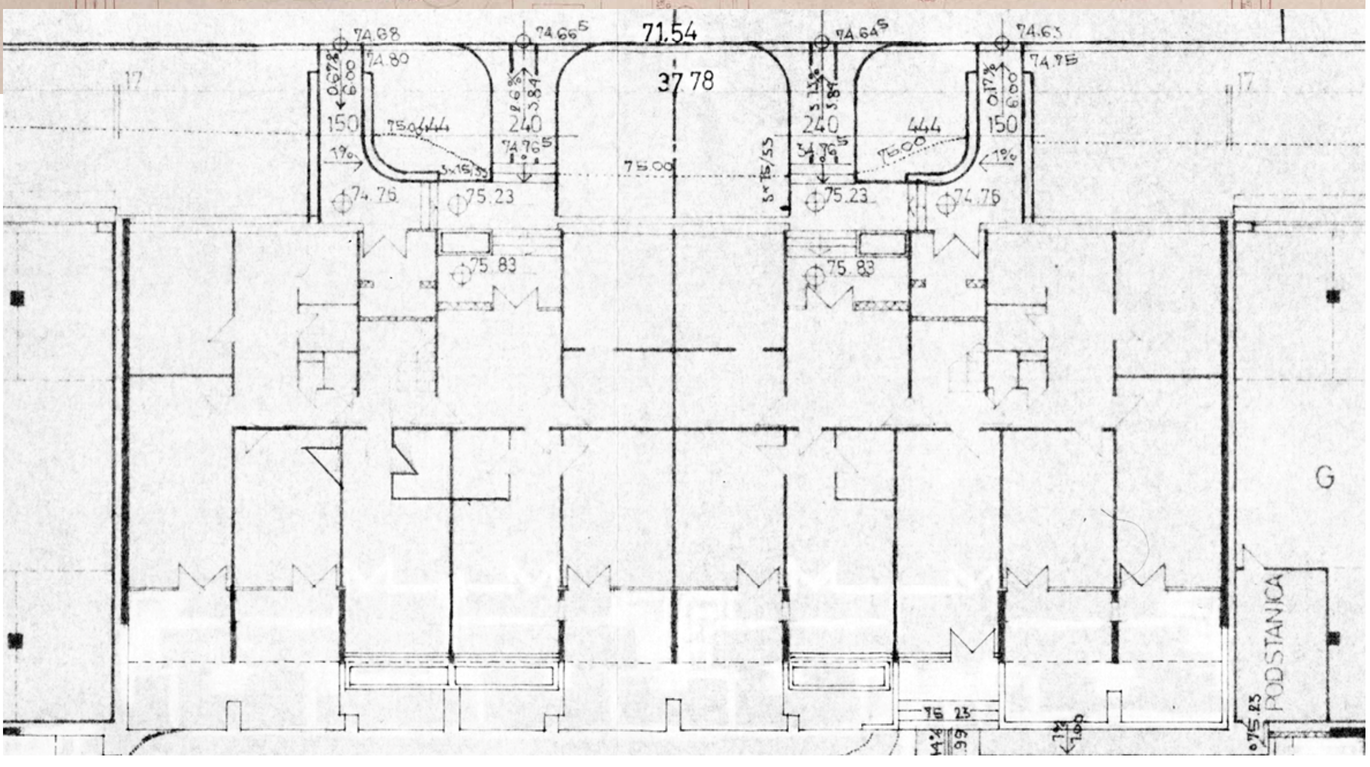
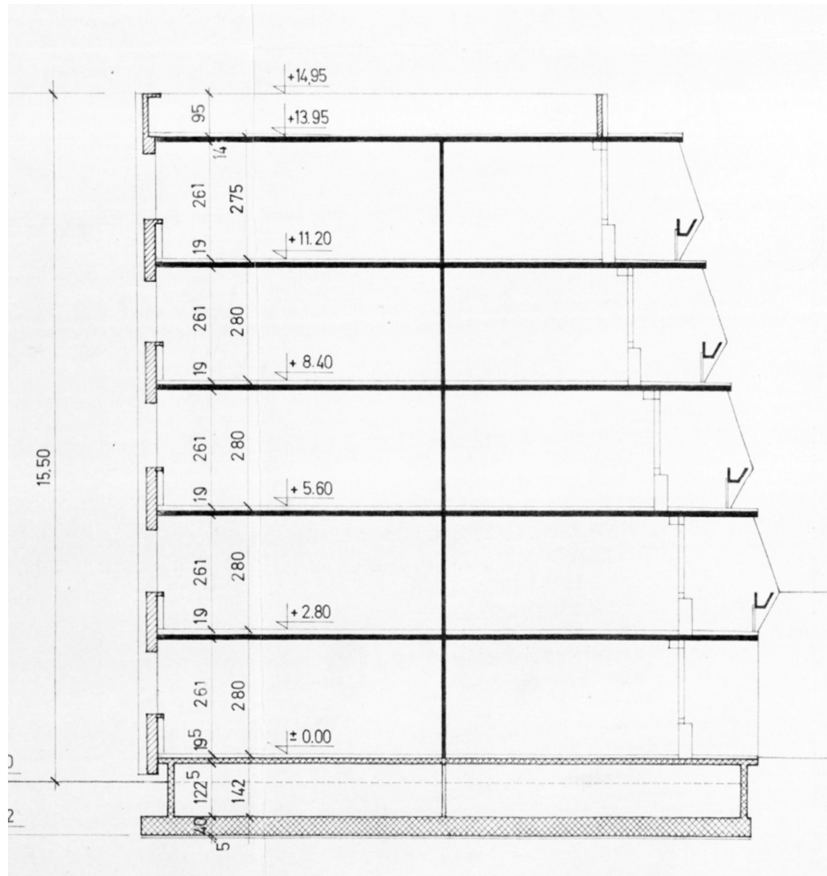
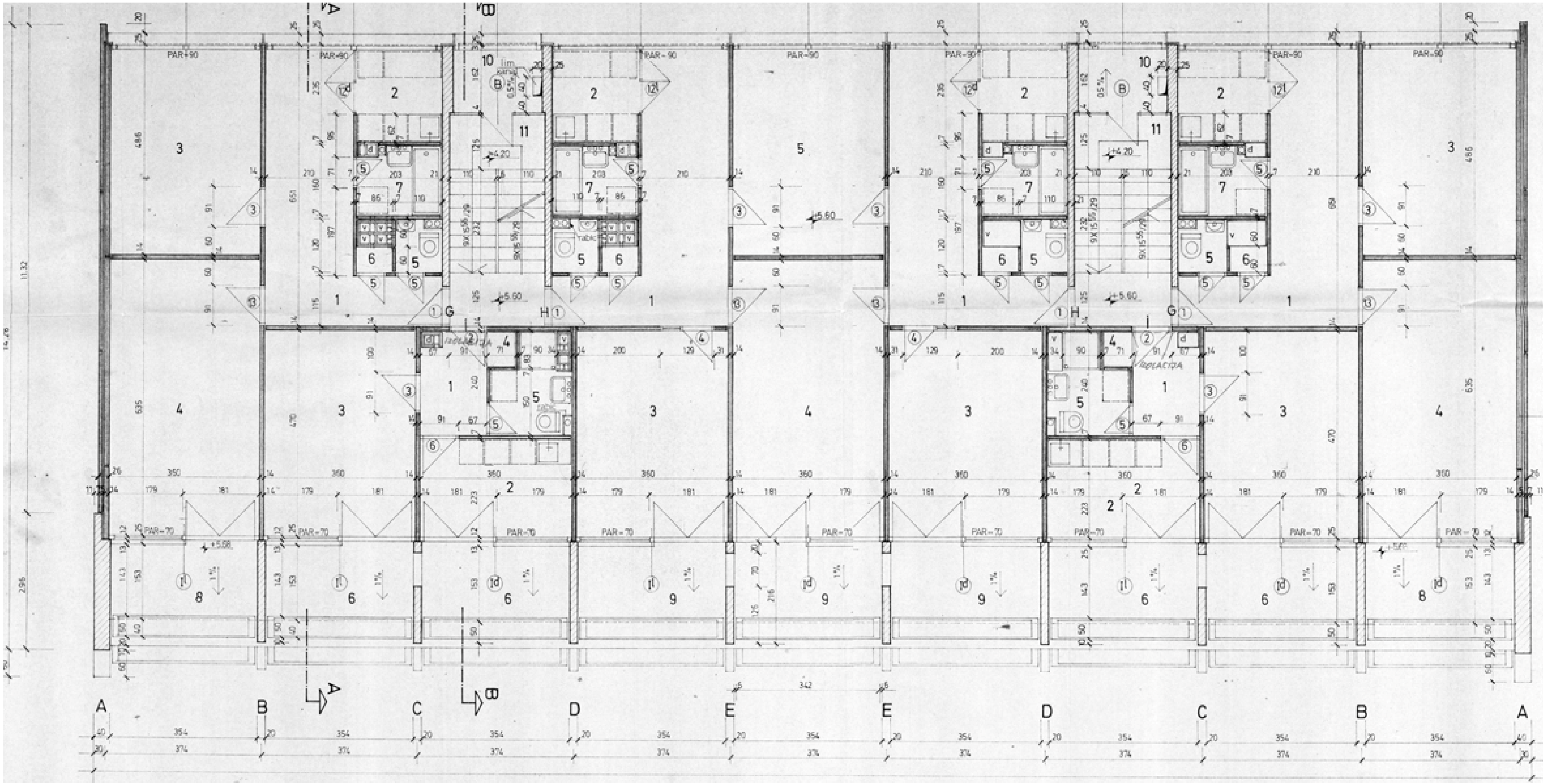
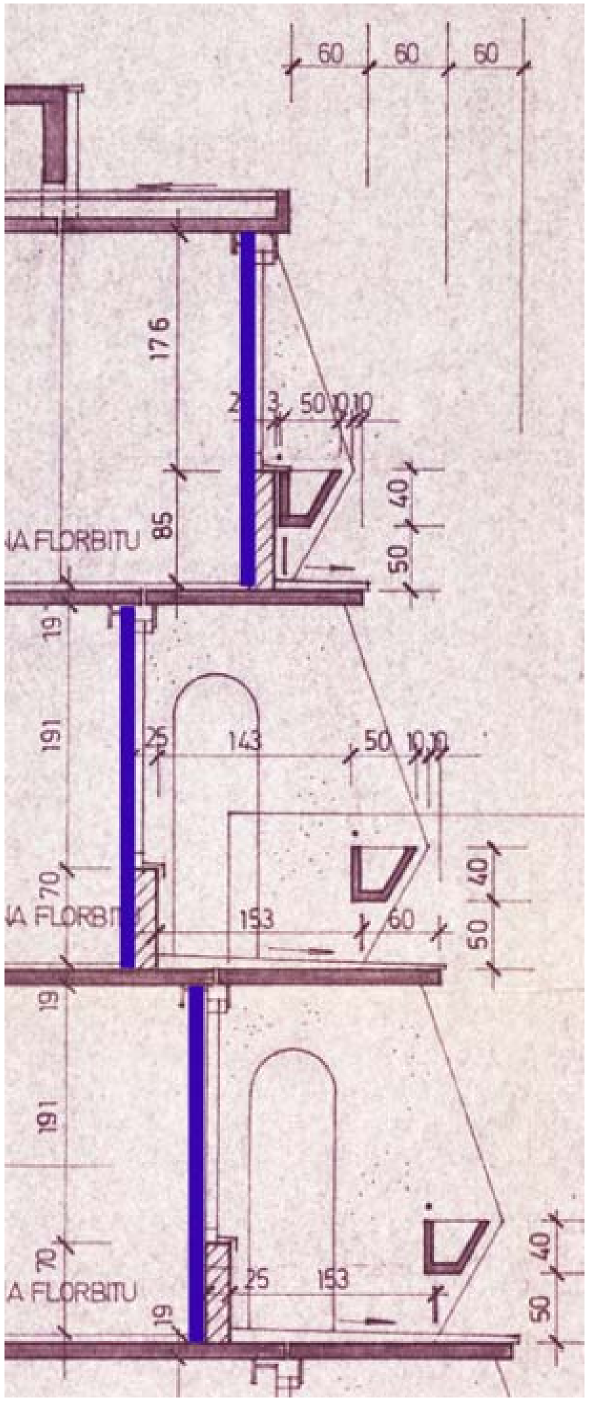


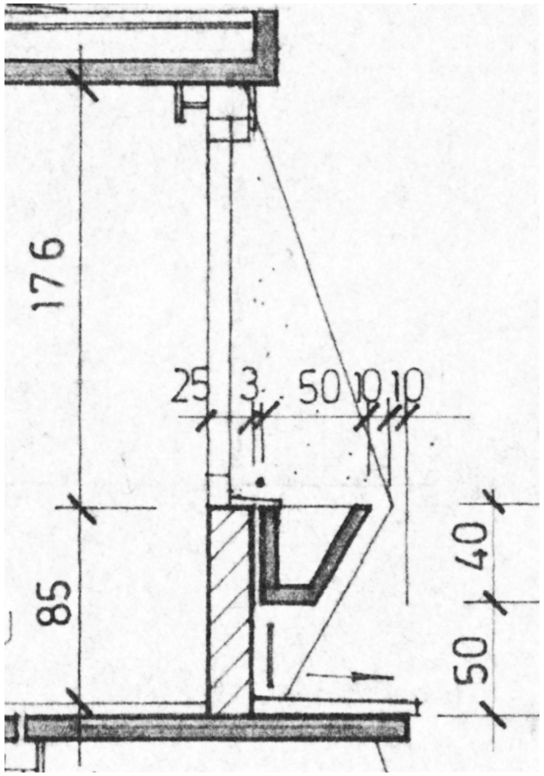
Figure: Building Model - Prefabricated panel system Trudbenik (*source: Historical Archives of Belgrade*)





Block No. 45_Atrium building Figure: Typical floor plan(*source: Historical Archives of Belgrade*)





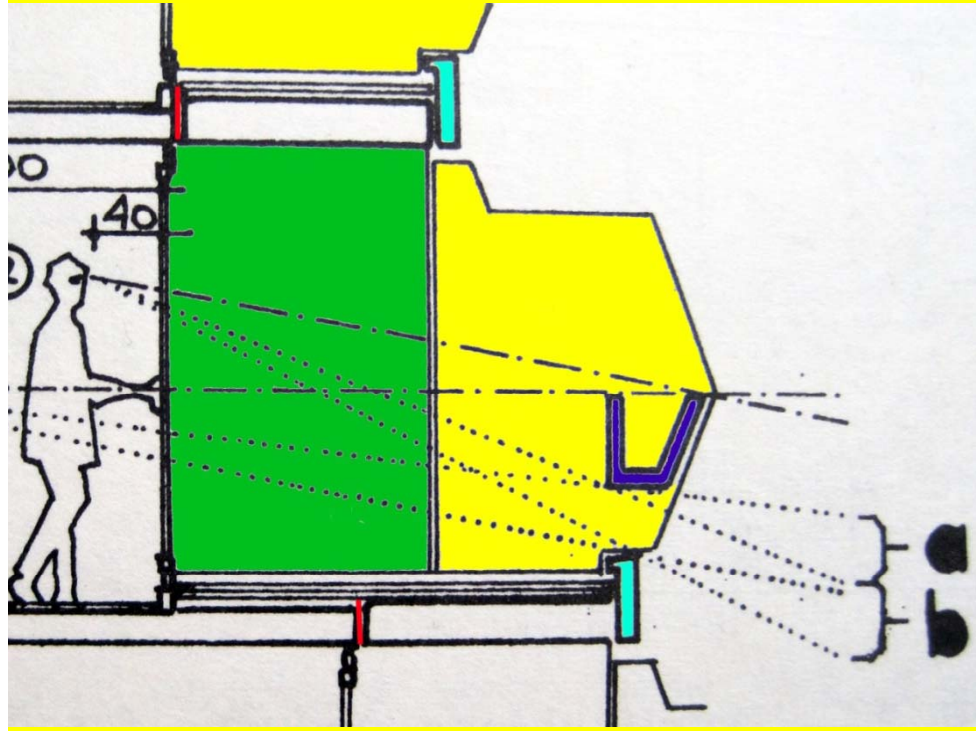
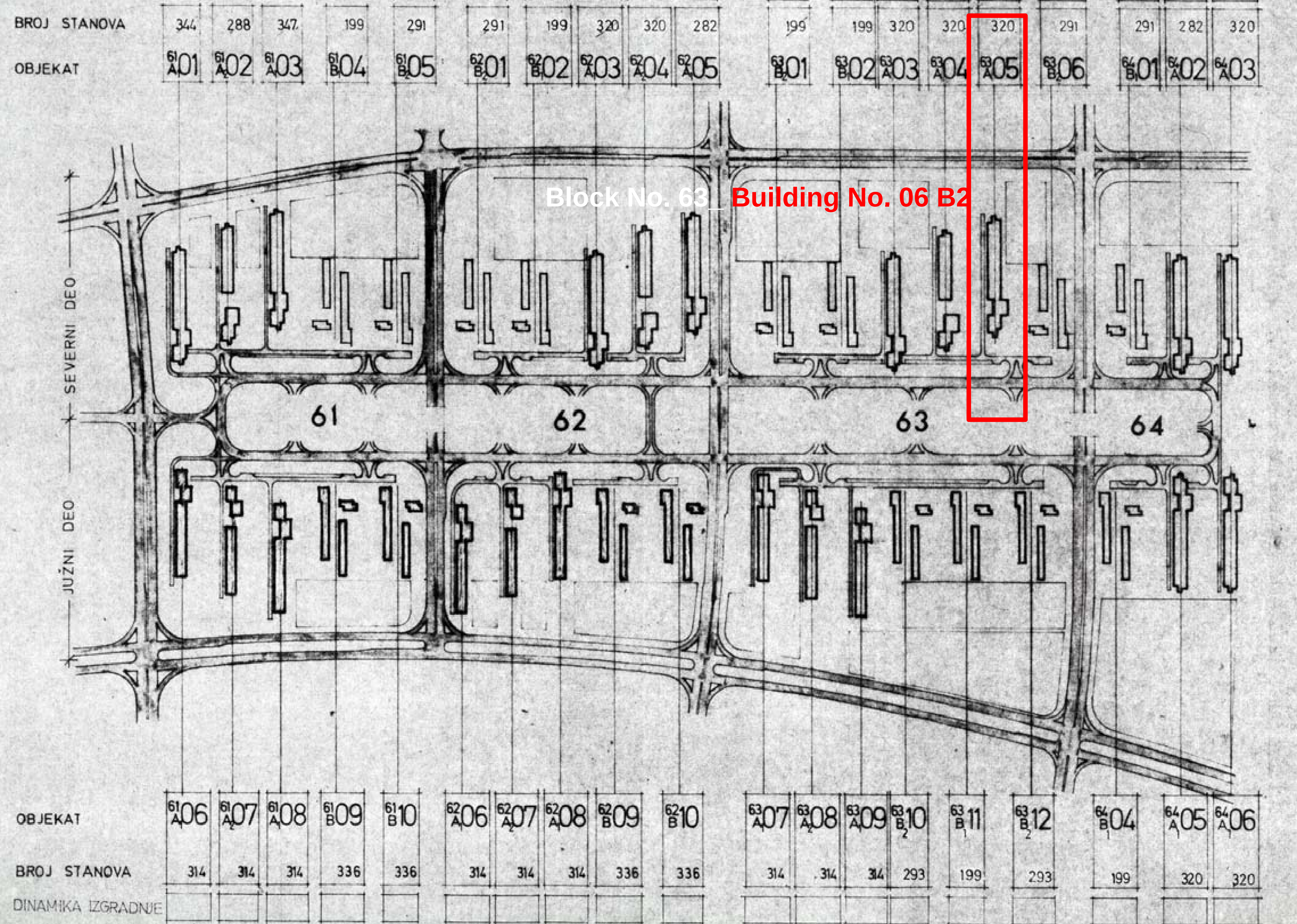


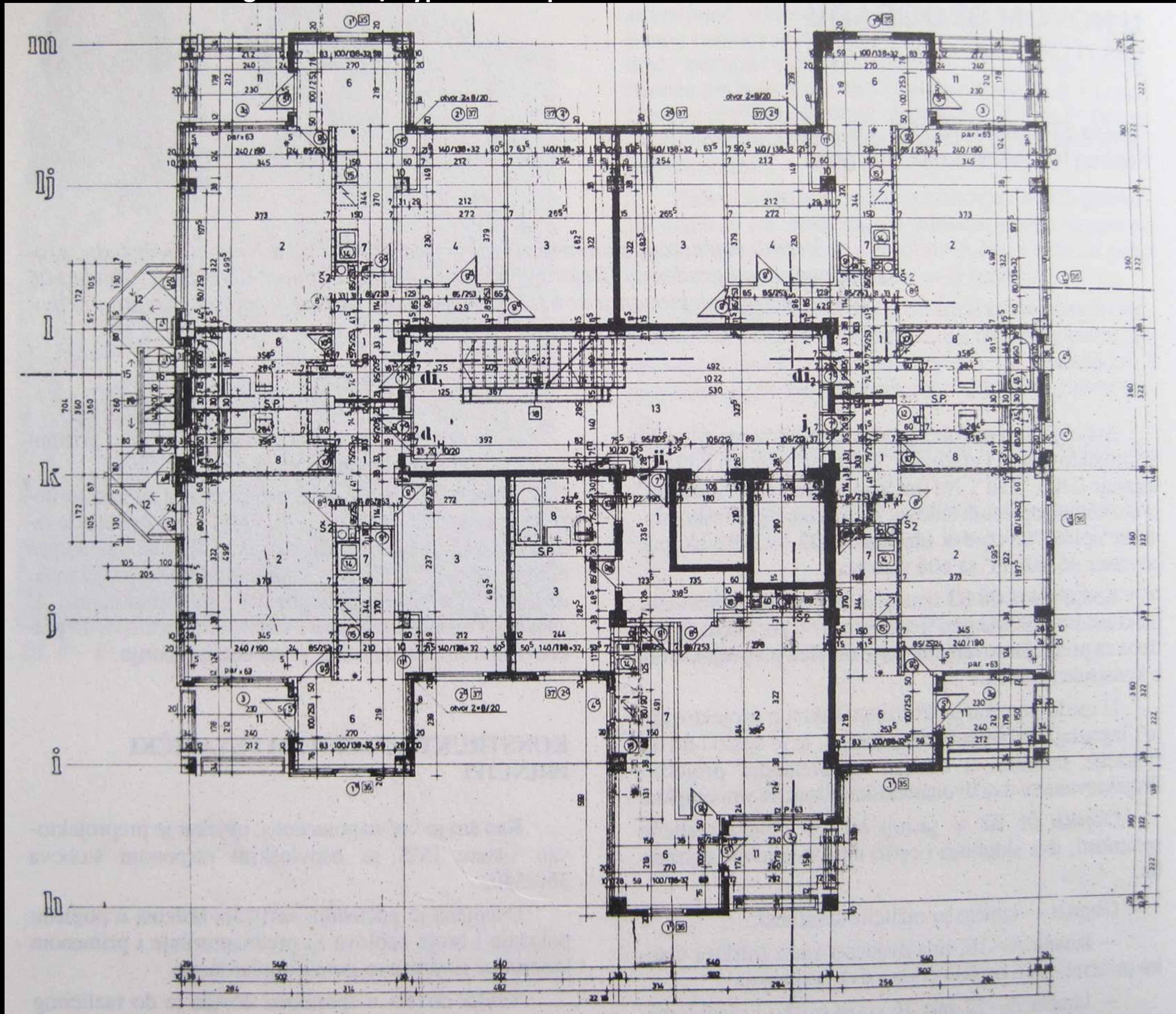
Figure: Prefabricated components for façade: balcony parapet, partition wall between balconies, fence, cornice,(*source: Historical Archives of Belgrade*)

***APPENDIX* - Block No. 63 : Building No. 06 B2**

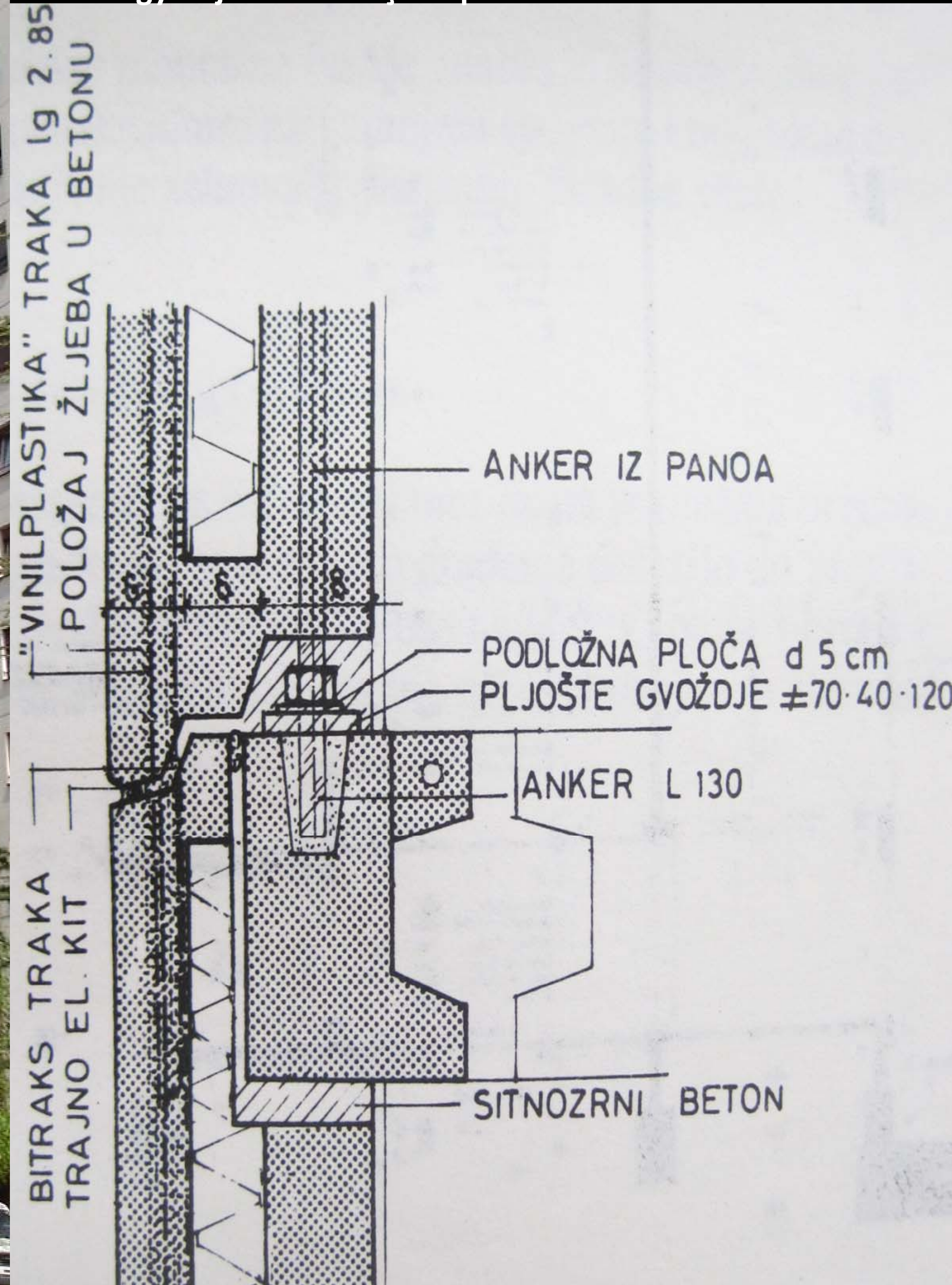


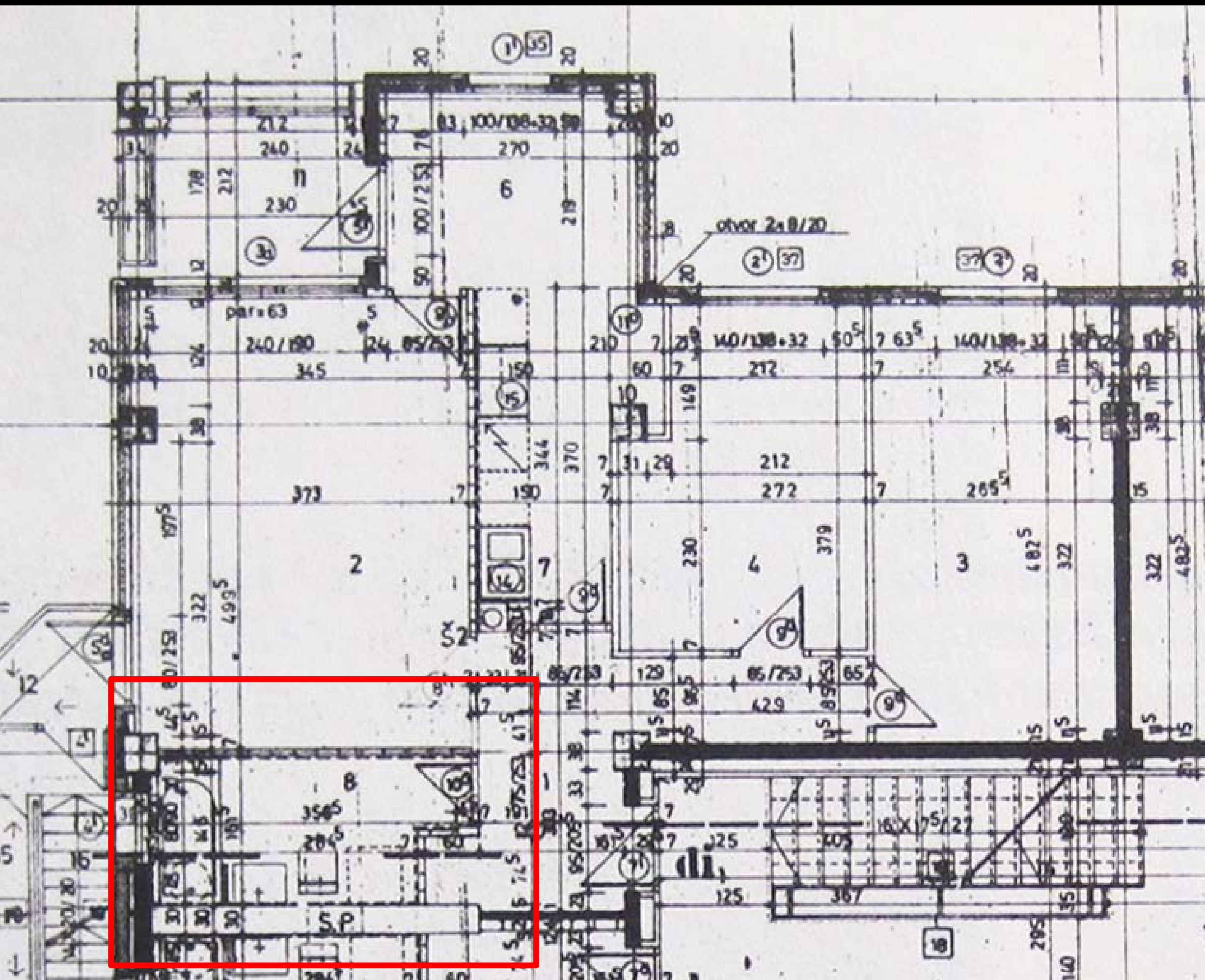
BROJ STANOVA
344 288 347 199 291 291 199 320 320 282 199 199 320 320 320 291 291 282 320
OBJEKAT
61 A 01 | 61 A2 02 | 61 A 03 | 61 B 04 | 61 B2 05 | 62 B2 01 | 62 B 02 | 62 A 03 | 62 A 04 | 62 A 05 | 63 B2 01 | 63 B 02 | 63 A 03 | 63 A 04 | 63 A 05 | 63 B2 06 | 64 B 01 | 64 A 02 | 64 A 03
Block No. 63_ Building No. 06 B2
SEVERNI DEO
JUŽNI DEO
61
62
63
64
OBJEKAT
61 A 06 | 61 A2 07 | 61 A 08 | 61 B 09 | 61 B 10 | 62 A 06 | 62 A2 07 | 62 A 08 | 62 B 09 | 62 B 10 | 63 A 07 | 63 A2 08 | 63 A 09 | 63 B2 10 | 63 B1 11 | 63 B2 12 | 64 B1 04 | 64 A1 05 | 64 A1 06
BROJ STANOVA
314 314 314 336 336 314 314 314 336 336 314 314 314 293 199 293 199 320 320
DINAMIKA IZGRADNJE

Block No. 63: Building No. 06 B2 / Typical floor plan of main tower C8

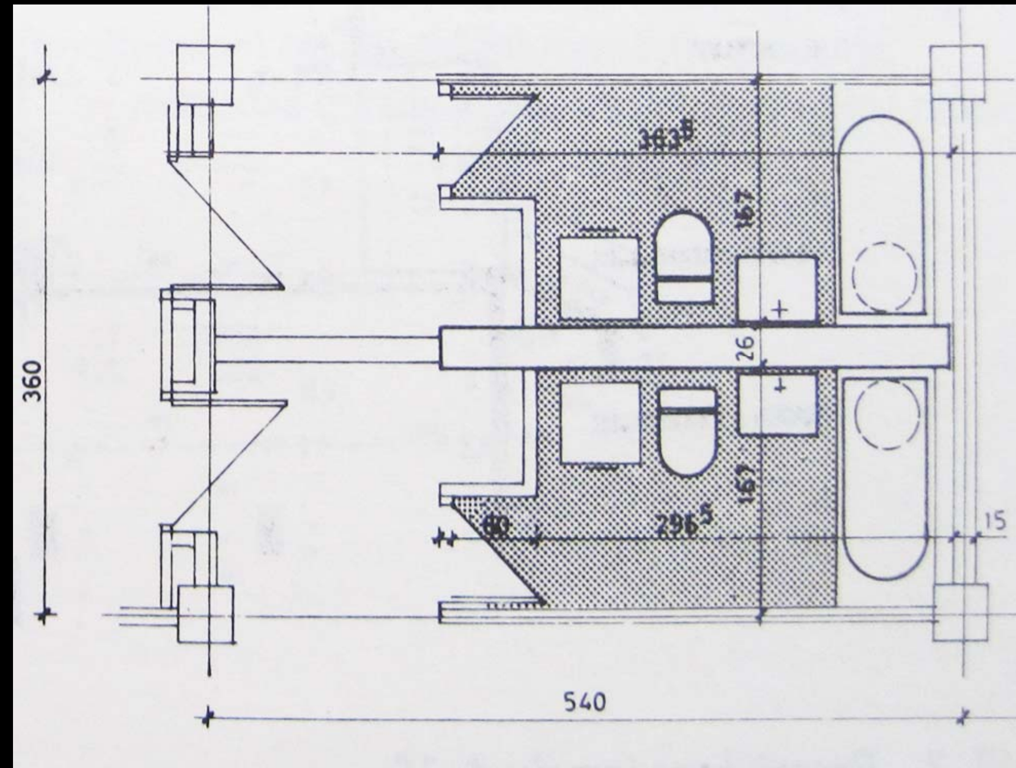


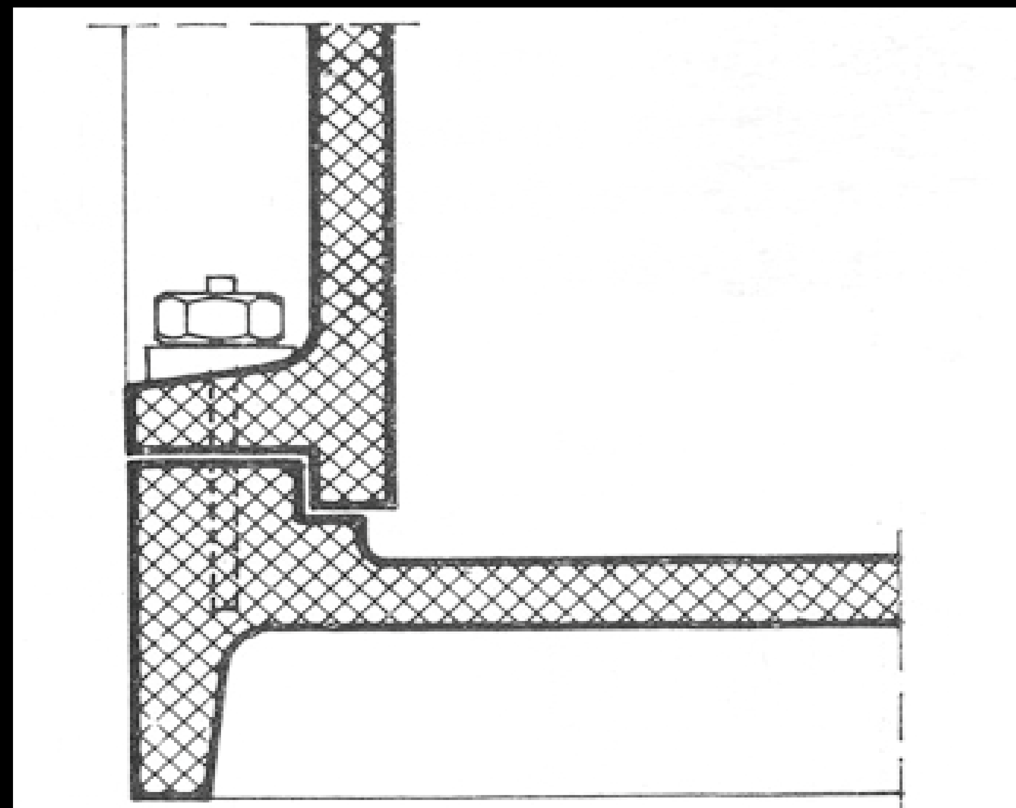
Block No. 63: Building No. 06 B2 / Technology of joints for façade panel



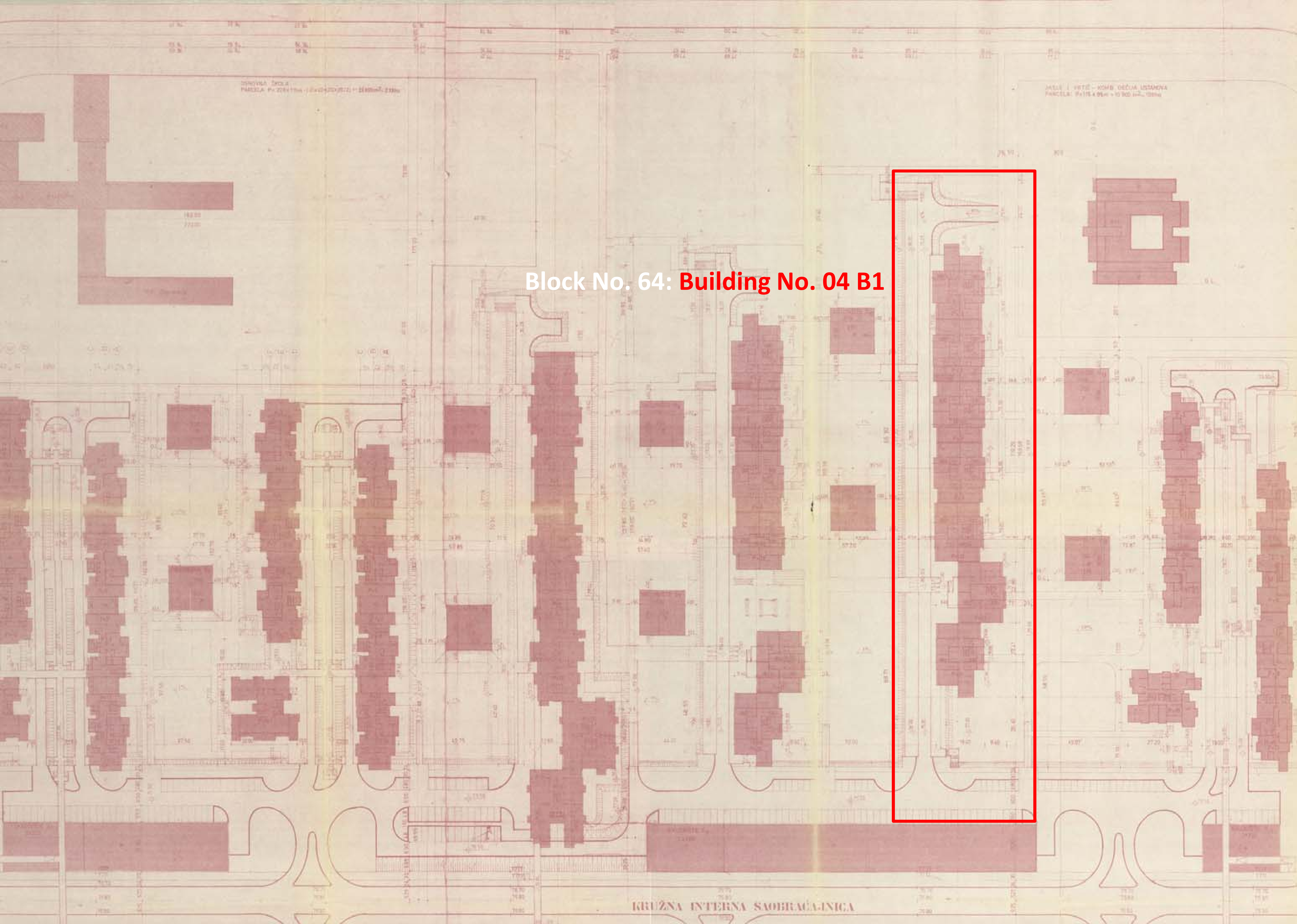


Block No. 63: Building No. 06 B2 a/ Prefabricated sanitary block

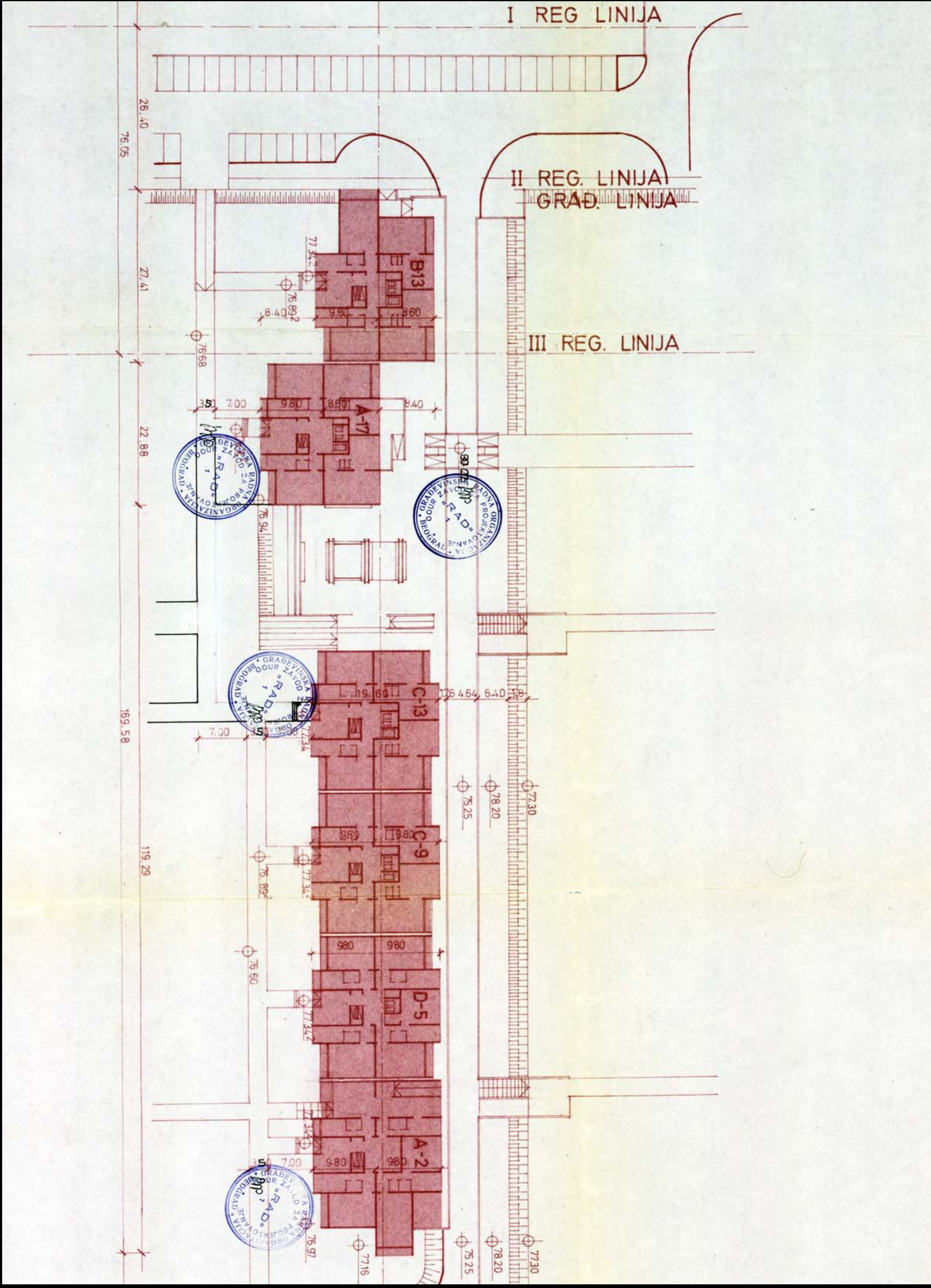




APPENDIX - **Block No. 64: Building No. 04 B1**

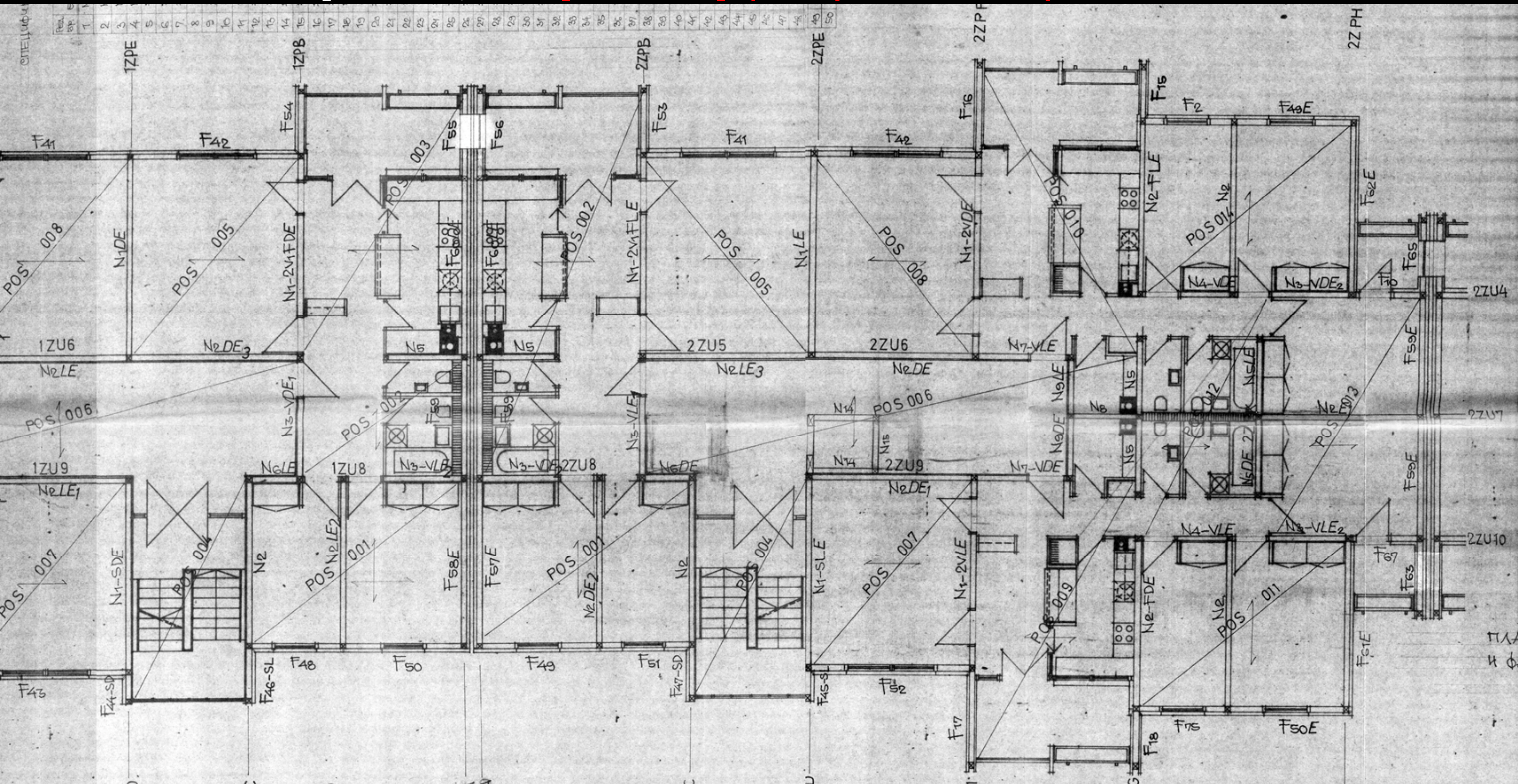


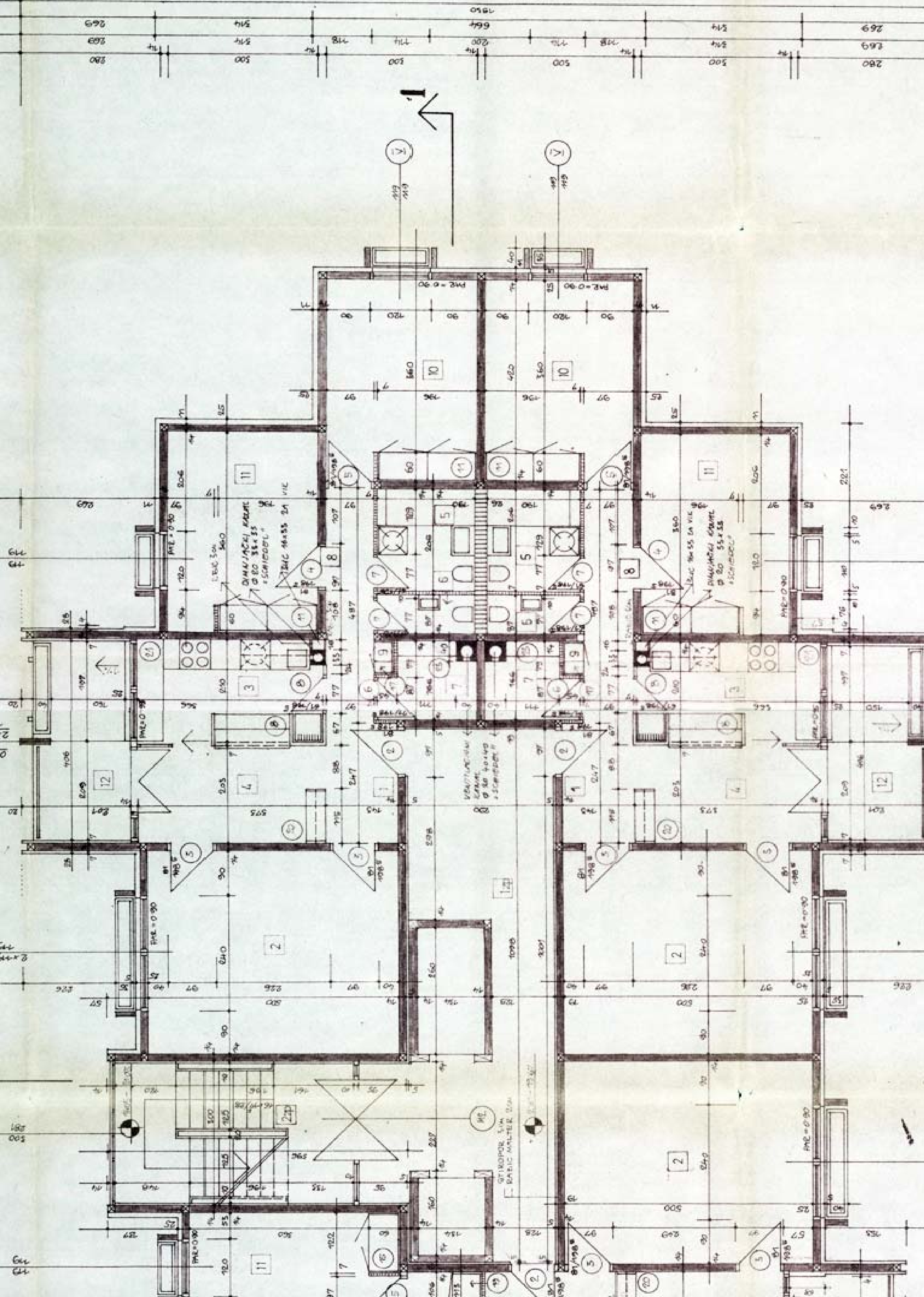
Block No. 64: Building No. 04 B1
KRUŽNA INTERNA SAOBRAĆAJNICA

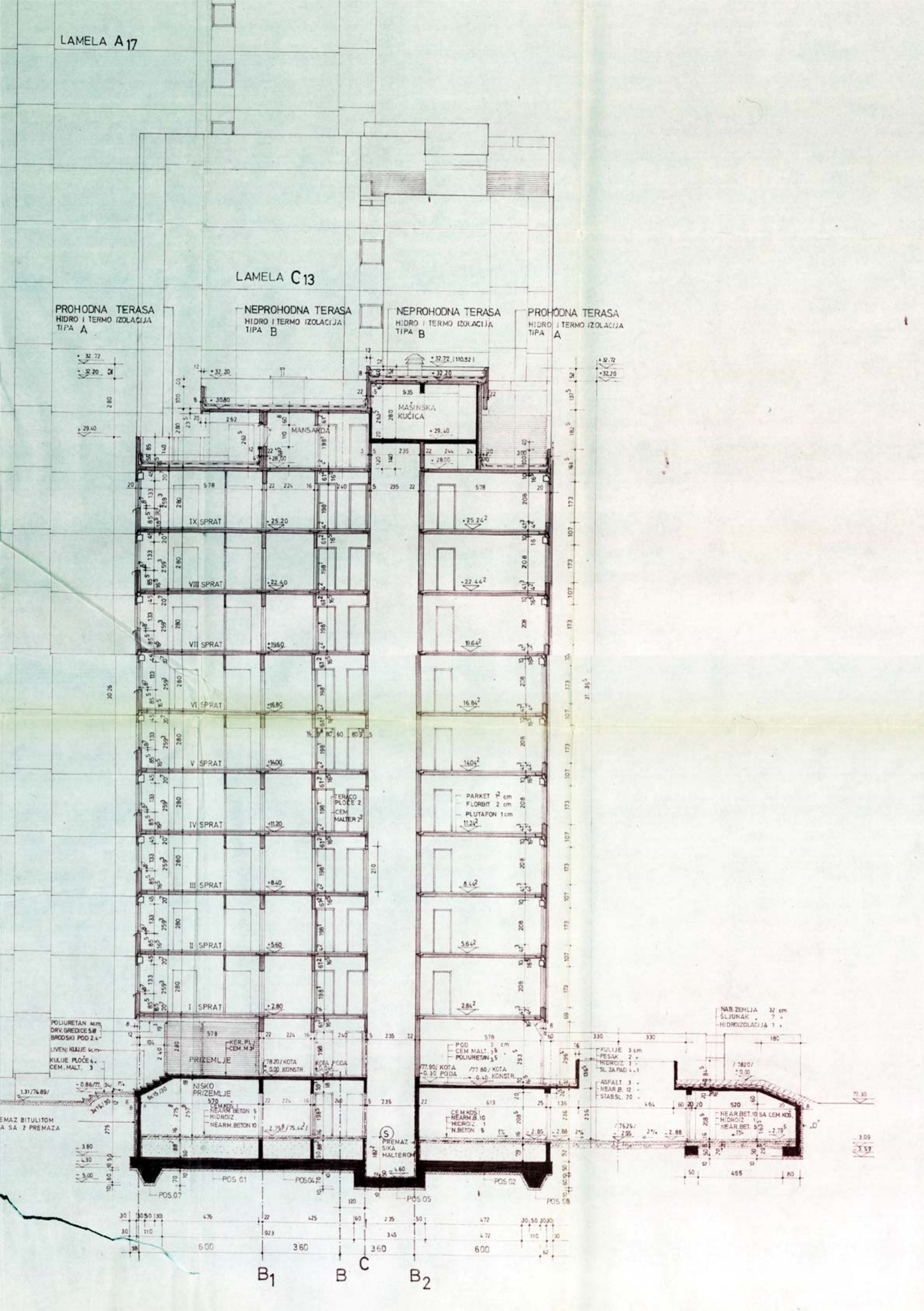


I REG. LINIJA
II REG. LINIJA
GRAD. LINIJA
III REG. LINIJA
B13
A-17
C-13
C-9
D-5
A-2
26.40
27.41
22.88
119.29
169.58
76.05
76.68
76.60
76.892
76.94
76.97
77.16
77.30
78.20
75.25
77.342
7.00
9.80
8.40
GRAĐEVINSKA RADNA ORGANIZACIJA ZAVOD ZA PROJEKTOVANJE "RAD" OOUR 1 BEOGRAD

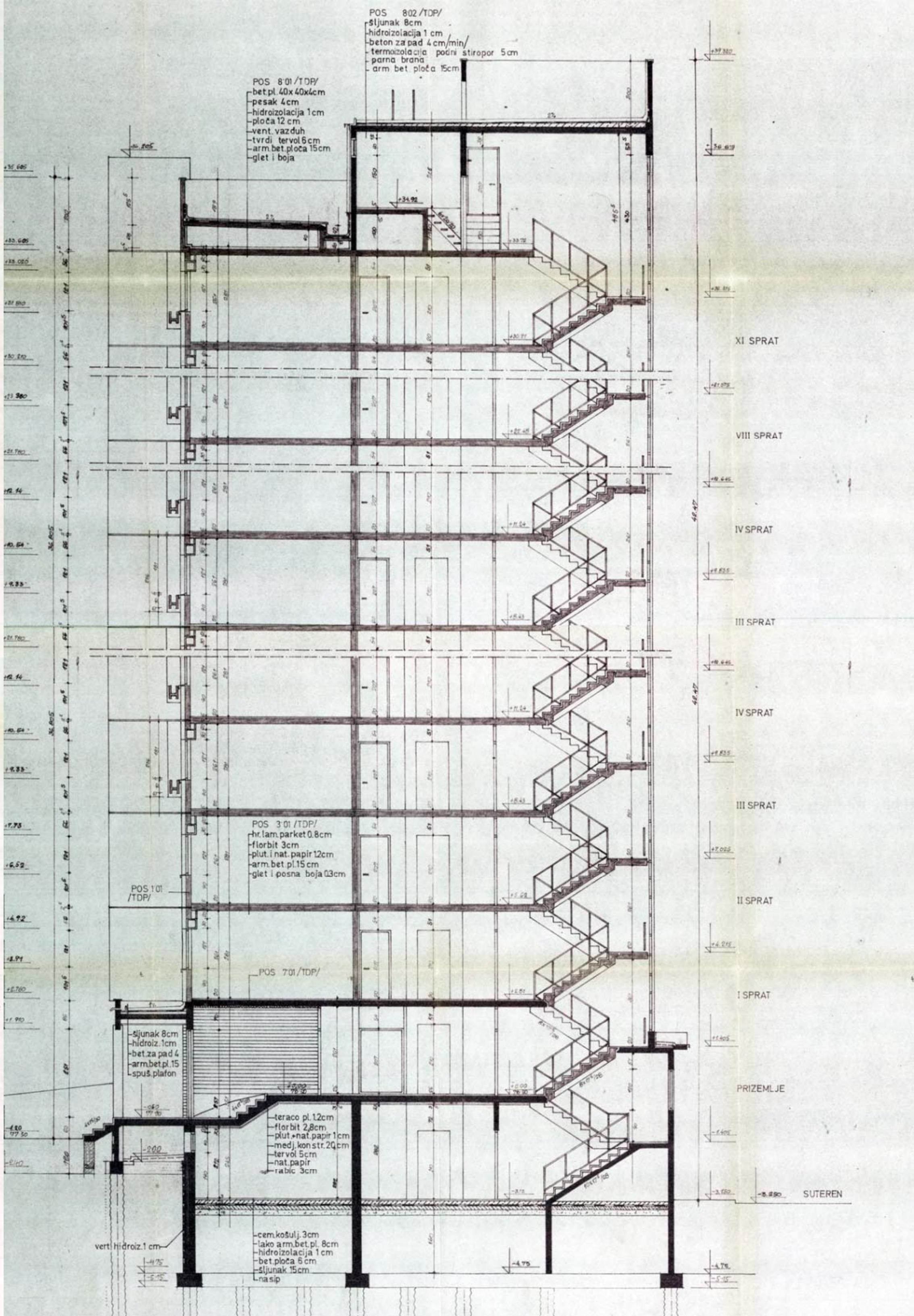
Block No. 64: Building No. 04 B1 / ***Building Model - huge panel system Rad-Balency***







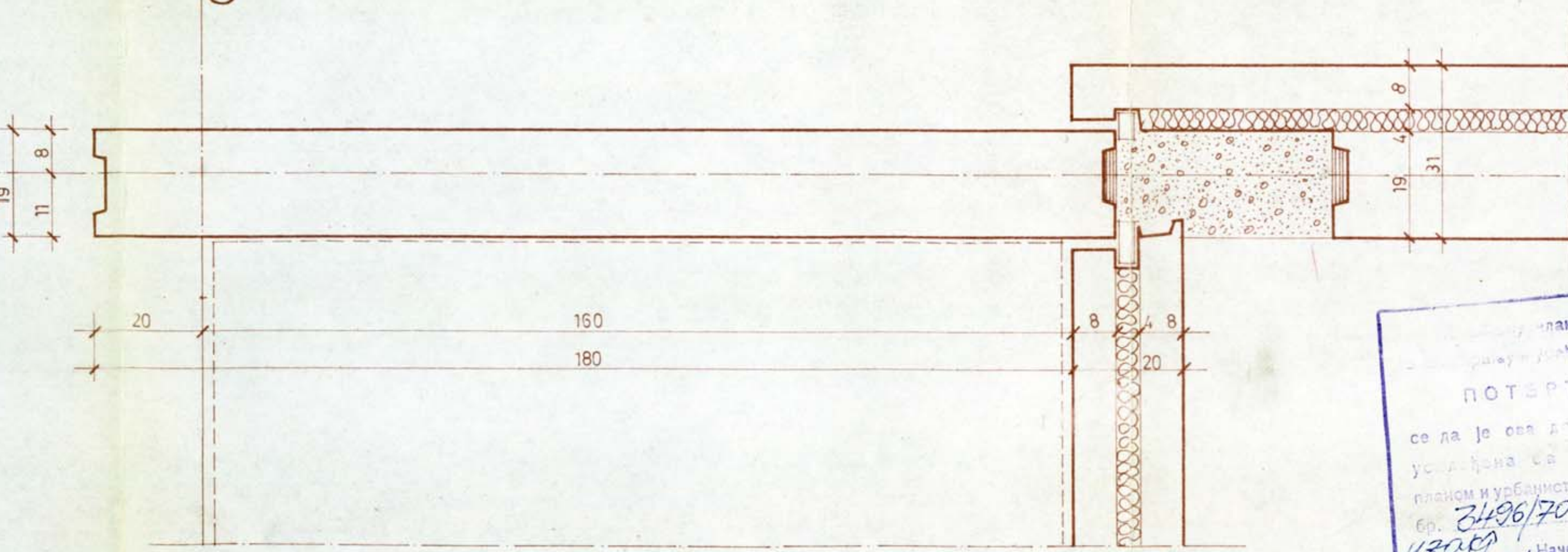
LAMELA A17
LAMELA C13
PROHODNA TERASA
HIDRO I TERMO IZOLACIJA
TIPA A
NEPROHODNA TERASA
HIDRO I TERMO IZOLACIJA
TIPA B
NEPROHODNA TERASA
HIDRO I TERMO IZOLACIJA
TIPA B
PROHODNA TERASA
HIDRO I TERMO IZOLACIJA
TIPA A
MAŠINSKA KUĆICA
MANSARDA
IX SPRAT
VIII SPRAT
VII SPRAT
VI SPRAT
V SPRAT
IV SPRAT
III SPRAT
II SPRAT
I SPRAT
PRIZEMLJE
NISKO PRIZEMLJE
PARKET 1 cm
FLORBIT 2 cm
PLUTAFON 1 cm
B1
B
C
B2



POS 8'02 /TDP/
šljunak 8cm
hidroizolacija 1 cm
beton za pad 4 cm/min/
termoizolacija podni stiropor 5cm
parna brana
arm bet ploča 15cm
POS 8'01 /TDP/
bet.pl. 40x40x4cm
pesak 4cm
hidroizolacija 1cm
ploča 12 cm
vent. vazduh
tvrdi tervol 6 cm
arm.bet.ploča 15cm
glet i boja
XI SPRAT
VIII SPRAT
IV SPRAT
III SPRAT
IV SPRAT
III SPRAT
II SPRAT
I SPRAT
PRIZEMLJE
SUTEREN
POS 3'01 /TDP/
hr.lam.parket 0.8cm
florbit 3cm
plut.i nat.papir 1.2cm
arm.bet.pl.15cm
glet i posna boja 0.3cm
POS 1'01 /TDP/
POS 7'01 /TDP/
šljunak 8cm
hidroiz. 1cm
bet.za pad 4
arm.bet.pl.15
spuš.plafon
teraco pl. 1.2cm
florbit 2.8cm
plut.+nat.papir 1cm
medj.kon.str. 20cm
tervol 5cm
nat.papir
rabic 3cm
cem.košulj. 3cm
lako arm.bet.pl. 8cm
hidroizolacija 1 cm
bet.ploča 6 cm
šljunak 15cm
nasip
vert.hidroiz.1 cm

DETALJ LAMELE B - 13

R = 1:10



APPENDIX:

Calculation of energy needs for heating for parapet façade structure and flat roof: Three models for building envelope improvement

TRANSMISIONI KOEFICIJENT Ht

OBJEKAT - BLOK 21 V.1 BEOGRAD
Klimatska zona -II

Spoljna projektna temperatura .... Te = -12.1 C
Prosecna unutrasnja temperatura objekta Ti = 20.0 C

PREGLED POVRSINA I KOEFICIJENATA PROLAZA TOPLOTE OMOTACA OBJEKTA

Br	Naziv	Oznaka	A m2	U W/m2K	Fx -	Q W
1	**Spoljni prozor**	**LOKAL**	**167.7**	**3.30**	1.0	553.4
2	**Spoljni prozor**	**STANO**	**1570.1**	**3.05**	1.0	4788.8
3	**Spoljni zid**	**SZ 34**	**2774.2**	**1.70**	1.0	4716.1
4	**Pod na tlu**	**PNT**	**916.8**	**0.37**	0.5	169.6
5	**Medjuspr.konstr.iznad otvor.prostora**	**E**	**470.5**	**1.15**	1.0	541.1
6	**Ravan krov iznad grejanog prostora**	**RK 1**	**811.9**	**0.71**	1.0	576.4
7	**Ravan krov iznad grejanog prostora**	**RK 2**	**575.4**	**1.93**	1.0	1110.5

Povrsina spoljnjeg omotaca objekta ... A = 7286.58 m2
Zapremina objekta .... Ve = 19227.00 m3

Zapremina objekta .... V = 15739.00 m3

Faktor oblika objekta fo=A/V .... fo = 0.38 1/m

Transmisioni gubici prolaza toplote
Fx x U x A .... = 12456.0 W/K

Linijski trasmisioni gubici Htb

Povrsina omotaca sa racunatim linijskim
vezama (toplotnim mostovima) .... A1 = 1737.8 m2
Povrsina omotaca za dodatak linijskih
veza (toplotnih mostova) .... A2 = 5548.8 m2
Uticaj linijskih veza .... dUtb = 0.1 W/m2K

Dodatak za uticaj linijskih veza .... Htb = 554.9 W/K

TRANSMISIONI KOEFICIJENT PROLAZA TOPLOTE
Ht = (Fx x U x A) + Htb............. Ht = 13010.9 W/K

Specificni transmisioni gubitak toplote Ht'= 1.79 W/m2K

Najveca dopustena vrednost spec.transmisionih
gubitaka toplote (Tabela 3.4.2.3.1) H'tmax = 0.80 W/m2K

KOEFICIJENT VENTILACIONOG GUBITKA TOPLOTE Hv (W/K)
Hv=0,33 x V x n
Zapremina objekta .... V = 15739.00 m3
Broj izmena vazduha na cas-tabela 3.4.2.2 n= 1.20 1/h
VENTILACIONI KOEFICIJENT .... Hv = 6232.6 W/K

Ht + Hv .... = 19243.5 W/K

Specificni zapreminski gubici toplote qv = 1.00 W/m3

UKUPNI GUBICI TOPLOTE U TOKU GREJNE SEZONE
(godisnja potrebna energije za nadoknadu gubitaka toplote kWh/a)

TRANSMISIONI GUBICI TOPLOTE
HD = 175 dana
Unutrasnja temperatura Tu =20.0 oC
Prosecna temperatura u toku grejne sezone Te = 5.6 oC
HDD = 20.00- 5.60 x 175 =2520

Qt = Ht x HDD x 24/1000

VENTILACIONI GUBICI TOPLOTE
Qv = Hv x HDD x 24/1000
Godisnja potrebna energija za nadoknadu gubitaka toplote (kWh/a)
Qh,ht = Qt + Qv
PRORACUN DOBITAKA TOPLOTE

PRORACUN DOBITAKA TOPLOTE OD LJUDI
Qlj = A x 1.8 x 12/24 x 175 x 24/1000
A = 6005.7 Korisna povrsina u m2
Odavanje toplote od ljudi 1.8 W/m2, prisutnost 12 casova tokom dana - tabela 6.5 u Pravilniku o EEZ

PRORACUN DOBITAKA TOPLOTE OD ELEKTRICNIH UREDJAJA
Qel = A x 30.0 x 175/365
Odavanje toplote od el.uredjaja 30 kWh/m2 - tabela 6.5 u Pravilniku

PRORACUN DOBITAKA TOPLOTE OD SUNCA KROZ PROZORE I BALKONSKA VRATA

SREDNJE SUME SUNCEVOG ZRACENJA I SREDNJE MESECNE TEMPERATURE

MESEC	I	II	III	IV	X	XI	XII	ZIMA
Sr.temp. C	0,9	3,0	7,3	12,5	12,7	7,2	2,6	5,6
Sever	17,42	22,38	36,04	44,64	38,78	29,16	17,93	145
Istok/Zap.	32,57	55,35	79,80	96,05	67,21	34,67	25,53	310
Jug	64,25	76,98	103,86	133,65	109,22	66,52	52,80	455
Horizont.	42,75	60,35	103,86	133,65	88,94	45,50	33,87	398

Povrsine prozora prema stranama sveta
Sever P = 773.0 m2 Fsh = 0.90
Istok P = 96.5 m2 Fsh = 0.90
Jug P = 759.5 m2 Fsh = 0.90
Zapad P = 108.8 m2 Fsh = 0.90
Horizontalna povrsina P = 0.0 m2 Fsh = 0.00

Qsol = Fsh x Asol x Ac x Isol x tau
Faktor stakla q,gl = 0.710
Faktor rama = 0.200
Neupravno zracenje = 0.900

PRORACUN DOBITAKA TOPLOTE OD SUNCA KROZ SPOLJNE ZIDOVE
Povrsine zidova prema stranama sveta
Sever P (m2) = 1409.7
Istok P (m2) = 184.4
Jug P (m2) = 867.9
Zapad P (m2) = 312.1
Emisivnost spoljne povrsine zida as,C = 0.6
Otpor prelazu toplote za spoljnu stranu zida Rs,c = 0.04 m2K/W
Koeficijent prolaza toplote zida Uc (m2K/W) = 1.70

POTREBNA ENERGIJA ZA GREJANJE Q H,nd (kWh/mesec)
(ENERGY NEEDS FOR HEATING - PER MONTH)
Tabela po mesecima:

MESEC	QH,ht	Qsol,gl	Qsol,c	Qsol	Qlj	Qel	Qint	QH,gn	**QH,nd**
Okt.	40457.5	21246.0	2486.2	23732.3	1556.7	5923.4	7480.1	31212.4	9245.2
Nov.	177348.1	32896.7	3680.2	36576.9	3891.7	14808.6	18700.3	55277.2	122070.9
Dec.	249118.6	25951.5	2888.9	28840.4	4021.4	15302.2	19323.6	48164.1	200954.6
Jan.	273457.8	31723.7	3543.1	35266.9	4021.4	15302.2	19323.6	54590.5	218867.3
Feb.	219837.7	40087.9	4620.9	44708.8	3632.2	13821.3	17453.6	62162.3	157675.4

```
Mart 181827.9 54052.0  6393.6 60445.6  4021.4 15302.2 19323.6 79769.2 102058.8
Apr.  41566.0 22102.2  2730.4 24832.6  1556.7  5923.4  7480.1 32312.7   9253.3
-----------------------------------------------------------------------------
```

Mesecni gubici kWh/m2 mesec/**ENERGY LOOSES kWh/m2 per month**

Oktobar	qH,nd =	1.54
Novembar	qH,nd =	20.33
Decembar	qH,nd =	33.46
Januar	qH,nd =	36.44
Februar	qH,nd =	26.25
Mart	qH,nd =	16.99
April	qH,nd =	1.54

Godisnja potrebna energija za grejanje qH,nd (kWh/m2a)

(ENERGY NEEDS FOR HEATING /year)

QH,an = 820125.3 / 6005.7 =136.56 (kWh/m2a)

QH,nd rel =136.56 / 70 = 195.08 %

Namena zgrade : Zgrada sa vise stanova
Energetski razred- **BUILDING ENERGY REAING: E**

***

IMPROVEMENT OF THE BUIDLING ENVELOPE BY EXCHANGING WINDOWS

TRANSMISIONI KOEFICIJENT Ht

OBJEKAT - BLOK 21 V 2 BEOGRAD
Klimatska zona -II

Spoljna projektna temperatura .... Te = -12.1 C
Prosecna unutrasnja temperatura objekta Ti = 20.0 C

PREGLED POVRSINA I KOEFICIJENATA PROLAZA TOPLOTE OMOTACA OBJEKTA

Br	Naziv	Oznaka	A m2	U W/m2K	Fx -	Q W
1	Spoljni prozor	LOKAL	167.7	3.30	1.0	553.4
2	Spoljni prozor	STAN	1570.1	1.40	1.0	2198.1
3	Spoljni zid	SZ 34	2774.2	1.70	1.0	4716.1
4	Pod na tlu	PPNT	916.8	0.37	0.5	169.6
5	Medjuspr.konstr.iznad otvor.prostora	E	470.5	1.15	1.0	541.1
6	Ravan krov iznad grejanog prostora	RK 1	811.9	0.71	1.0	576.4
7	Ravan krov iznad grejanog prostora	RK 2	575.4	1.93	1.0	1110.5

Povrsina spoljnjeg omotaca objekta ... A = 7286.58 m2
Zapremina objekta .... Ve = 19227.00 m3

Zapremina objekta .... V = 15739.00 m3

Faktor oblika objekta fo=A/V .... fo = 0.38 1/m

Transmisioni gubici prolaza toplote
Fx x U x A .... = 9865.3 W/K

Linijski trasmisioni gubici Htb

Povrsina omotaca sa racunatim linijskim
vezama (toplotnim mostovima) .... A1 = 1737.8 m2
Povrsina omotaca za dodatak linijskih
veza (toplotnih mostova) .... A2 = 5548.8 m2
Uticaj linijskih veza .... dUtb = 0.1 W/m2K

Dodatak za uticaj linijskih veza .... Htb = 554.9 W/K

TRANSMISIONI KOEFICIJENT PROLAZA TOPLOTE
Ht = (Fx x U x A) + Htb............. Ht = 10420.2 W/K

Specificni transmisioni gubitak toplote Ht'= 1.43 W/m2K

Najveca dopustena vrednost spec.transmisionih
gubitaka toplote (Tabela 3.4.2.3.1) H'tmax = 0.80 W/m2K

KOEFICIJENT VENTILACIONOG GUBITKA TOPLOTE Hv (W/K)
Hv=0,33 x V x n
Zapremina objekta .... V = 15739.00 m3
Broj izmena vazduha na cas-tabela 3.4.2.2 n= 0.50 1/h
VENTILACIONI KOEFICIJENT .... Hv = 2596.9 W/K

Ht + Hv .... = 13017.1 W/K

Specificni zapreminski gubici toplote qv = 0.68 W/m3

UKUPNI GUBICI TOPLOTE U TOKU GREJNE SEZONE
(godisnja potrebna energije za nadoknadu gubitaka toplote kWh/a)

TRANSMISIONI GUBICI TOPLOTE
HD = 175 dana
Unutrasnja temperatura Tu =20.0 oC
Prosecna temperatura u toku grejne sezone Te = 5.6 oC
HDD = 20.00- 5.60 x 175 =2520

Qt = Ht x HDD x 24/1000

VENTILACIONI GUBICI TOPLOTE
Qv = Hv x HDD x 24/1000
Godisnja potrebna energija za nadoknadu gubitaka toplote (kWh/a)
Qh,ht = Qt + Qv
PRORACUN DOBITAKA TOPLOTE

PRORACUN DOBITAKA TOPLOTE OD LJUDI
Qlj = A x 1.8 x 12/24 x 175 x 24/1000
A = 6005.7 Korisna povrsina u m2
Odavanje toplote od ljudi 1.8 W/m2, prisutnost 12 casova tokom dana
- tabela 6.5 u Pravilniku o EEZ

PRORACUN DOBITAKA TOPLOTE OD ELEKTRICNIH UREDJAJA
Qel = A x 30.0 x 175/365
Odavanje toplote od el.uredjaja 30 kWh/m2 - tabela 6.5 u Pravilniku

PRORACUN DOBITAKA TOPLOTE OD SUNCA KROZ PROZORE I BALKONSKA VRATA

SREDNJE SUME SUNCEVOG ZRACENJA I SREDNJE MESECNE TEMPERATURE

MESEC	I	II	III	IV	X	XI	XII	ZIMA
Sr.temp. C	0,9	3,0	7,3	12,5	12,7	7,2	2,6	5,6

Sever	17,42	22,38	36,04	44,64	38,78	29,16	17,93	145
Istok/Zap.	32,57	55,35	79,80	96,05	67,21	34,67	25,53	310
Jug	64,25	76,98	103,86	133,65	109,22	66,52	52,80	455
Horizont.	42,75	60,35	103,86	133,65	88,94	45,50	33,87	398

Povrsine prozora prema stranama sveta

Sever	P = 773.0 m2	Fsh = 0.90
Istok	P = 96.5 m2	Fsh = 0.90
Jug	P = 759.5 m2	Fsh = 0.90
Zapad	P = 312.1 m2	Fsh = 0.90
Horizontalna povrsina	P = 0.0 m2	Fsh = 0.00

Qsol = Fsh x Asol x Ac x Isol x tau

Faktor stakla q,gl = 0.610

Faktor rama = 0.200

Neupravno zracenje = 0.900

PRORACUN DOBITAKA TOPLOTE OD SUNCA KROZ SPOLJNE ZIDOVE

Povrsine zidova prema stranama sveta

Sever	P (m2) = 1409.7
Istok	P (m2) = 184.4
Jug	P (m2) = 867.9
Zapad	P (m2) = 312.1

Emisivnost spoljne povrsine zida as,C = 0.6

Otpor prelazu toplote za spoljnu stranu zida Rs,c = 0.04 m2K/W

Koeficijent prolaza toplote zida Uc (m2K/W) = 1.70

POTREBNA ENERGIJA ZA GREJANJE Q H,nd (kWh/mesec)

(ENERGY NEEDS FOR HEATING - PER MONTH)

Tabela po mesecima:

MESEC	QH,ht	Qsol,gl	Qsol,c	Qsol	Qlj	Qel	Qint	QH,gn	**QH,nd**
Okt.	27367.2	20344.4	2486.2	22830.6	1556.7	5923.4	7480.1	30310.7	0.0
Nov.	119965.8	31049.5	3680.2	34729.6	3891.7	14808.6	18700.3	53429.9	66535.9
Dec.	168514.5	24348.0	2888.9	27236.9	4021.4	15302.2	19323.6	46560.5	121954.0
Jan.	184978.5	29872.9	3543.1	33416.1	4021.4	15302.2	19323.6	52739.7	132238.8
Feb.	148707.6	38889.6	4620.9	43510.5	3632.2	13821.3	17453.6	60964.1	87743.5
Mart	122996.2	52851.8	6393.6	59245.4	4021.4	15302.2	19323.6	78569.0	44427.2
Apr.	28117.0	22076.7	2730.4	24807.0	1556.7	5923.4	7480.1	32287.1	0.0

Mesecni gubici kWh/m2 mesec - **ENERGY LOOSES kWh/m2 per month**

Oktobar	qH,nd =	0.00
Novembar	qH,nd =	11.08
Decembar	qH,nd =	20.31
Januar	qH,nd =	22.02
Februar	qH,nd =	14.61
Mart	qH,nd =	7.40
April	qH,nd =	0.00

Godisnja potrebna energija za grejanje qH,nd (kWh/m2a)

(ENERGY NEEDS FOR HEATING -per year)

QH,an = 452899.4 / 6005.7 = 75.41 (kWh/m2a)

QH,nd rel = 75.41 / 70 = 107.73 %

Namena zgrade : Zgrada sa vise stanova

Energetski razred - **BUILDING ENERGY REAING : D**

IMPROVEMENT OF THE BUIDLING ENVELOPE BY ISOLATION OF THE EXTERIOR WALLS AND FLAT ROOF

TRANSMISIONI KOEFICIJENT Ht

OBJEKAT - BLOK 21 V 4 BEOGRAD
Klimatska zona -II

Spoljna projektna temperatura .... Te = -12.1 C
Prosecna unutrasnja temperatura objekta Ti = 20.0 C

PREGLED POVRSINA I KOEFICIJENATA PROLAZA TOPLOTE OMOTACA OBJEKTA

Br	Naziv	Oznaka	A m2	U W/m2K	Fx -	Q W
1	Spoljni prozor	LOKAL	167.7	3.30	1.0	553.4
2	Spoljni prozor	STAN	1570.1	3.05	1.0	4788.8
3	Spoljni zid	SZ 34	2774.2	0.30	1.0	823.9
4	Pod na tlu	PNT	916.8	0.37	0.5	169.6
5	Medjuspr.konstr.iznad otvor.prostora	E	470.5	0.27	1.0	128.9
6	Ravan krov iznad grejanog prostora	RK 1	811.9	0.14	1.0	114.5
7	Ravan krov iznad grejanog prostora	RK 2	575.4	0.16	1.0	92.6

Povrsina spoljnjeg omotaca objekta ... A = 7286.58 m2
Zapremina objekta .... Ve = 19227.00 m3

Zapremina objekta .... V = 15739.00 m3

Faktor oblika objekta fo=A/V .... fo = 0.38 1/m

Transmisioni gubici prolaza toplote
Fx x U x A .... = 6671.8 W/K

Linijski trasmisioni gubici Htb

Povrsina omotaca sa racunatim linijskim
vezama (toplotnim mostovima) .... A1 = 1737.8 m2
Povrsina omotaca za dodatak linijskih
veza (toplotnih mostova) .... A2 = 5548.8 m2
Uticaj linijskih veza .... dUtb = 0.1 W/m2K

Dodatak za uticaj linijskih veza .... Htb = 554.9 W/K

TRANSMISIONI KOEFICIJENT PROLAZA TOPLOTE
Ht = (Fx x U x A) + Htb............. Ht = 7226.7 W/K

Specificni transmisioni gubitak toplote Ht'= 0.99 W/m2K

Najveca dopustena vrednost spec.transmisionih
gubitaka toplote (Tabela 3.4.2.3.1) H'tmax = 0.80 W/m2K

KOEFICIJENT VENTILACIONOG GUBITKA TOPLOTE Hv (W/K)
Hv=0,33 x V x n
Zapremina objekta .... V = 15739.00 m3
Broj izmena vazduha na cas-tabela 3.4.2.2 n= 1.20 1/h
VENTILACIONI KOEFICIJENT .... Hv = 6232.6 W/K

Ht + Hv .... = 13459.3 W/K

Specificni zapreminski gubici toplote qv = 0.70 W/m3

UKUPNI GUBICI TOPLOTE U TOKU GREJNE SEZONE

(godisnja potrebna energije za nadoknadu gubitaka toplote kWh/a)

TRANSMISIONI GUBICI TOPLOTE
HD = 175 dana
Unutrasnja temperatura Tu =20.0 oC
Prosecna temperatura u toku grejne sezone Te = 5.6 oC
HDD = 20.00- 5.60 x 175 =2520

Qt = Ht x HDD x 24/1000

VENTILACIONI GUBICI TOPLOTE
Qv = Hv x HDD x 24/1000
Godisnja potrebna energija za nadoknadu gubitaka toplote (kWh/a)
Qh,ht = Qt + Qv
PRORACUN DOBITAKA TOPLOTE

PRORACUN DOBITAKA TOPLOTE OD LJUDI
Qlj = A x 1.8 x 12/24 x 175 x 24/1000
A = 6005.7 Korisna povrsina u m2
Odavanje toplote od ljudi 1.8 W/m2, prisutnost 12 casova tokom dana
- tabela 6.5 u Pravilniku o EEZ

PRORACUN DOBITAKA TOPLOTE OD ELEKTRICNIH UREDJAJA
Qel = A x 30.0 x 175/365
Odavanje toplote od el.uredjaja 30 kWh/m2 - tabela 6.5 u Pravilniku

PRORACUN DOBITAKA TOPLOTE OD SUNCA KROZ PROZORE I BALKONSKA VRATA

SREDNJE SUME SUNCEVOG ZRACENJA I SREDNJE MESECNE TEMPERATURE

MESEC	I	II	III	IV	X	XI	XII	ZIMA
Sr.temp. C	0,9	3,0	7,3	12,5	12,7	7,2	2,6	5,6
Sever	17,42	22,38	36,04	44,64	38,78	29,16	17,93	145
Istok/Zap.	32,57	55,35	79,80	96,05	67,21	34,67	25,53	310
Jug	64,25	76,98	103,86	133,65	109,22	66,52	52,80	455
Horizont.	42,75	60,35	103,86	133,65	88,94	45,50	33,87	398

Povrsine prozora prema stranama sveta

Sever	P = 773.0 m2	Fsh = 0.90
Istok	P = 96.5 m2	Fsh = 0.90
Jug	P = 759.5 m2	Fsh = 0.90
Zapad	P = 312.1 m2	Fsh = 0.90
Horizontalna povrsina	P = 0.0 m2	Fsh = 0.00

Qsol = Fsh x Asol x Ac x Isol x tau
Faktor stakla q,gl = 0.710
Faktor rama = 0.200
Neupravno zracenje = 0.900

PRORACUN DOBITAKA TOPLOTE OD SUNCA KROZ SPOLJNE ZIDOVE
Povrsine zidova prema stranama sveta
Sever P (m2) = 1409.7
Istok P (m2) = 184.4
Jug P (m2) = 867.9
Zapad P (m2) = 312.1
Emisivnost spoljne povrsine zida as,C = 0.6
Otpor prelazu toplote za spoljnu stranu zida Rs,c = 0.04 m2K/W
Koeficijent prolaza toplote zida Uc (m2K/W) = 0.30

POTREBNA ENERGIJA ZA GREJANJE Q H,nd (kWh/mesec)
(ENERGY NEEDS FOR HEATING - PER MONTH)
Tabela po mesecima:

MESEC	QH,ht	Qsol,gl	Qsol,c	Qsol	Qlj	Qel	Qint	QH,gn	**QH,nd**
Okt.	28296.9	23679.5	434.4	24113.9	1556.7	5923.4	7480.1	31594.0	0.0
Nov.	124041.0	36139.6	642.9	36782.5	3891.7	14808.6	18700.3	55482.8	68558.2

Dec.	174238.9	28339.5	504.7	28844.2	4021.4	15302.2	19323.6	48167.8	126071.1
Jan.	191262.2	34770.2	619.0	35389.2	4021.4	15302.2	19323.6	54712.8	136549.4
Feb.	153759.2	45265.0	807.3	46072.3	3632.2	13821.3	17453.6	63525.9	90233.3
Mart	127174.3	61516.0	1117.0	62633.0	4021.4	15302.2	19323.6	81956.6	45217.7
Apr.	29072.1	25695.8	477.0	26172.8	1556.7	5923.4	7480.1	33652.9	0.0

Mesecni gubici kWh/m2 mesec - **ENERGY LOOSES kWh/m2 per month**

Oktobar	qH,nd =	0.00
Novembar	qH,nd =	11.42
Decembar	qH,nd =	20.99
Januar	qH,nd =	22.74
Februar	qH,nd =	15.02
Mart	qH,nd =	7.53
April	qH,nd =	0.00

Godisnja potrebna energija za grejanje qH,nd (kWh/m2a)
(ENERGY NEEDS FOR HEATING -per year)

QH,an = 466629.8 / 6005.7 = 77.70 (kWh/m2a)

QH,nd rel = 77.70 / 70 = 111.00 %

Namena zgrade : Zgrada sa vise stanova
Energetski razred-**BUILDING ENERGY REAING : D**

IMPROVEMENT OF THE BUIDLING ENVELOPE BY ISOLATION OF THE EXTERIOR WALLS AND FLAT ROOF AND EXCHANGING THE WINDOWS

TRANSMISIONI KOEFICIJENT Ht

OBJEKAT - BLOK 21 V 5 BEOGRAD
Klimatska zona -II

Spoljna projektna temperatura .... Te = -12.1 C
Prosecna unutrasnja temperatura objekta Ti = 20.0 C

PREGLED POVRSINA I KOEFICIJENATA PROLAZA TOPLOTE OMOTACA OBJEKTA

Br	Naziv	Oznaka	A m2	U W/m2K	Fx -	Q W
1	Spoljni prozor	LOKAL	167.7	3.30	1.0	553.4
2	Spoljni prozor	STAN	1570.1	1.40	1.0	2198.1
3	Spoljni zid	SZ 34	2774.2	0.30	1.0	823.9
4	Pod na tlu	PNT	916.8	0.37	0.5	169.6
5	Medjuspr.konstr.iznad otvor.prostora	E	470.5	0.27	1.0	128.9
6	Ravan krov iznad grejanog prostora	RK 1	811.9	0.14	1.0	114.5
7	Ravan krov iznad grejanog prostora	RK 2	575.4	0.16	1.0	92.6

Povrsina spoljnjeg omotaca objekta ... A = 7286.58 m2
Zapremina objekta .... Ve = 19227.00 m3

Zapremina objekta .... V = 15739.00 m3

Faktor oblika objekta fo=A/V .... fo = 0.38 1/m

Transmisioni gubici prolaza toplote
Fx x U x A .... = 4081.1 W/K

Linijski trasmisioni gubici Htb

Povrsina omotaca sa racunatim linijskim
vezama (toplotnim mostovima) .... A1 = 1737.8 m2
Povrsina omotaca za dodatak linijskih
veza (toplotnih mostova) .... A2 = 5548.8 m2
Uticaj linijskih veza .... dUtb = 0.1 W/m2K

Dodatak za uticaj linijskih veza .... Htb = 554.9 W/K

TRANSMISIONI KOEFICIJENT PROLAZA TOPLOTE
Ht = (Fx x U x A) + Htb............. Ht = 4636.0 W/K

Specificni transmisioni gubitak toplote Ht'= 0.64 W/m2K

Najveca dopustena vrednost spec.transmisionih
gubitaka toplote (Tabela 3.4.2.3.1) H'tmax = 0.80 W/m2K

KOEFICIJENT VENTILACIONOG GUBITKA TOPLOTE Hv (W/K)
Hv=0,33 x V x n
Zapremina objekta .... V = 15739.00 m3
Broj izmena vazduha na cas-tabela 3.4.2.2 n= 0.50 1/h
VENTILACIONI KOEFICIJENT .... Hv = 2596.9 W/K

Ht + Hv .... = 7232.9 W/K

Specificni zapreminski gubici toplote qv = 0.38 W/m3

UKUPNI GUBICI TOPLOTE U TOKU GREJNE SEZONE
(godisnja potrebna energije za nadoknadu gubitaka toplote kWh/a)

TRANSMISIONI GUBICI TOPLOTE
HD = 175 dana
Unutrasnja temperatura Tu =20.0 oC
Prosecna temperatura u toku grejne sezone Te = 5.6 oC
HDD = 20.00- 5.60 x 175 =2520

Qt = Ht x HDD x 24/1000

VENTILACIONI GUBICI TOPLOTE
Qv = Hv x HDD x 24/1000
Godisnja potrebna energija za nadoknadu gubitaka toplote (kWh/a)
Qh,ht = Qt + Qv
PRORACUN DOBITAKA TOPLOTE

PRORACUN DOBITAKA TOPLOTE OD LJUDI
Qlj = A x 1.8 x 12/24 x 175 x 24/1000
A = 6005.7 Korisna povrsina u m2
Odavanje toplote od ljudi 1.8 W/m2, prisutnost 12 casova tokom dana
- tabela 6.5 u Pravilniku o EEZ

PRORACUN DOBITAKA TOPLOTE OD ELEKTRICNIH UREDJAJA
Qel = A x 30.0 x 175/365
Odavanje toplote od el.uredjaja 30 kWh/m2 - tabela 6.5 u Pravilniku

PRORACUN DOBITAKA TOPLOTE OD SUNCA KROZ PROZORE I BALKONSKA VRATA

SREDNJE SUME SUNCEVOG ZRACENJA I SREDNJE MESECNE TEMPERATURE

MESEC	I	II	III	IV	X	XI	XII	ZIMA
Sr.temp. C	0,9	3,0	7,3	12,5	12,7	7,2	2,6	5,6
Sever	17,42	22,38	36,04	44,64	38,78	29,16	17,93	145
Istok/Zap.	32,57	55,35	79,80	96,05	67,21	34,67	25,53	310

Jug	64,25	76,98	103,86	133,65	109,22	66,52	52,80	455
Horizont.	42,75	60,35	103,86	133,65	88,94	45,50	33,87	398

Povrsine prozora prema stranama sveta

Sever	P = 773.0 m2	Fsh = 0.90
Istok	P = 96.5 m2	Fsh = 0.90
Jug	P = 759.5 m2	Fsh = 0.90
Zapad	P = 312.1 m2	Fsh = 0.90
Horizontalna povrsina	P = 0.0 m2	Fsh = 0.00

Qsol = Fsh x Asol x Ac x Isol x tau
Faktor stakla q,gl = 0.610
Faktor rama = 0.200
Neupravno zracenje = 0.900

PRORACUN DOBITAKA TOPLOTE OD SUNCA KROZ SPOLJNE ZIDOVE
Povrsine zidova prema stranama sveta

Sever	P (m2) = 1409.7
Istok	P (m2) = 184.4
Jug	P (m2) = 867.9
Zapad	P (m2) = 312.1

Emisivnost spoljne povrsine zida as,C = 0.6
Otpor prelazu toplote za spoljnu stranu zida Rs,c = 0.04 m2K/W
Koeficijent prolaza toplote zida Uc (m2K/W) = 0.30

POTREBNA ENERGIJA ZA GREJANJE Q H,nd (kWh/mesec)
(ENERGY NEEDS FOR HEATING - PER MONTH)
Tabela po mesecima:

MESEC	QH,ht	Qsol,gl	Qsol,c	Qsol	Qlj	Qel	Qint	QH,gn	**QH,nd**
Okt.	15206.5	20344.4	434.4	20778.7	1556.7	5923.4	7480.1	28258.8	0.0
Nov.	66658.7	31049.5	642.9	31692.4	3891.7	14808.6	18700.3	50392.7	16266.0
Dec.	93634.7	24348.0	504.7	24852.7	4021.4	15302.2	19323.6	44176.3	49458.4
Jan.	102782.9	29872.9	619.0	30492.0	4021.4	15302.2	19323.6	49815.6	52967.3
Feb.	82629.1	38889.6	807.3	39696.9	3632.2	13821.3	17453.6	57150.5	25478.6
Mart	68342.6	52851.8	1117.0	53968.8	4021.4	15302.2	19323.6	73292.4	0.0
Apr.	15623.1	22076.7	477.0	22553.7	1556.7	5923.4	7480.1	30033.8	0.0

Mesecni gubici kWh/m2 mesec **ENERGY LOOSES kWh/m2 per month**

Oktobar	qH,nd =	0.00
Novembar	qH,nd =	2.71
Decembar	qH,nd =	8.24
Januar	qH,nd =	8.82
Februar	qH,nd =	4.24
Mart	qH,nd =	0.00
April	qH,nd =	0.00

Godisnja potrebna energija za grejanje qH,nd (kWh/m2a)
(ENERGY NEEDS FOR HEATING -per year)

QH,an = 144170.3 / 6005.7 = 24.01 (kWh/m2a)

QH,nd rel = 24.01 / 70 = 34.29 %

Namena zgrade : Zgrada sa vise stanova
Energetski razred-**BUILDING ENERGY REAING : B**

APPENDIX:
Energy need for heating (200m² module): Consumption and Production balance

Information for 200m2 Modul Unit from Block 21

Data

Modul number	1	-	
Area	200	m2	
Installed heating power	8	kW	
Annual heating consumption	8800	kWh/a	
Total heating consumption	8800	kWh/a	
Consumption subject to seasonal heat storage	5844	kWh/a	

Characteristics of the storage

Thermal storage capacity per m3	48	kWh/m3	
Part of the needed energy subject to accumulation	66,41%		
Security factor	1,00		
Watertank volume	121,75	m3	
Price per m3	42,13	Euro/m3	
Total price	5.128,77	Euro	
Price of the collectors	117,59	Euro/m2	
Surface of the collectors	11	m2	
Total price	1293,46	Euro	
Fittings, heat exchangers, pumps	711,40	Euro	
Total solar collecting installation	2004,86	Euro	
Price of heat pump	178,94	Euro/kW	
Power of the heat pump	3	kW	
Total price of heat pump	536,81	Euro	
Total area	200	m2	
Factor for heating surface	0,7		
Отопляема площ	140	m2	
Price of floor heating REHAU	17,89	Euro/m2	Collector box, zone devices, floor finish, insulation layers, elastical component
Price of floor heating REHAU	2505,11	Euro	
Total price for collectors, accummulation, heat pump, etc.	10.175,55	Euro	
Alternative cattle	0	Euro for each	
Price of cattles	0	Euro	
Price of radiators	0	Euro per module	
Price of radiators	0	лв.	
Total for alternative installation	0	лв.	
Annual consumption of thermal energy	8,8	MWh	
Price	1	Euro/m2	
Annual saving	200,00	Euro	
Inflation of energy price	7,00%		
Discount rate	2,00%		
Total price for collectors, accummulation, heat pump, etc.	-10175,54543	euro	
Total price for collectors, accummulation, heat pump, etc.	-10175,54543	euro	
Investment	-10.175,55	euro	
Investment per m2	-50,88	euro/m2	
Simple return of investment	51	years	
Real return of investment (with discount rate)	16	years	

Heating needs

Heating per module	8800			
Annual daydegress	2520	Calculated:		2517,995
Average interior temperature	19,35			

	January	February	March	April	May	June	July	August	September	October	November	December
Coefficient of coincidence	1	1	1	0,82	0	0	0	0	0	0,5	1	1
Month	January	February	March	April	May	June	July	August	September	October	November	December
Days per month	31	28	31	30	31	30	31	31	30	31	30	31
Outside temperature	1,4	3,1	7,6	12,9	18,1	21	23	22,7	18	12,9	7,1	2,7
Daydegrees monthly	556,45	455	364,25	158,67	0	0	0	0	0	99,975	367,5	516,15
Part of heating energy to total annual energy	22,08%	18,06%	14,45%	6,30%	0,00%	0,00%	0,00%	0,00%	0,00%	3,97%	14,58%	20,48%
Part for heating kWh	1943	1589	1272	554	0	0	0	0	0	349	1283	1802

Sum of heating needs

Total heating consumption 8800

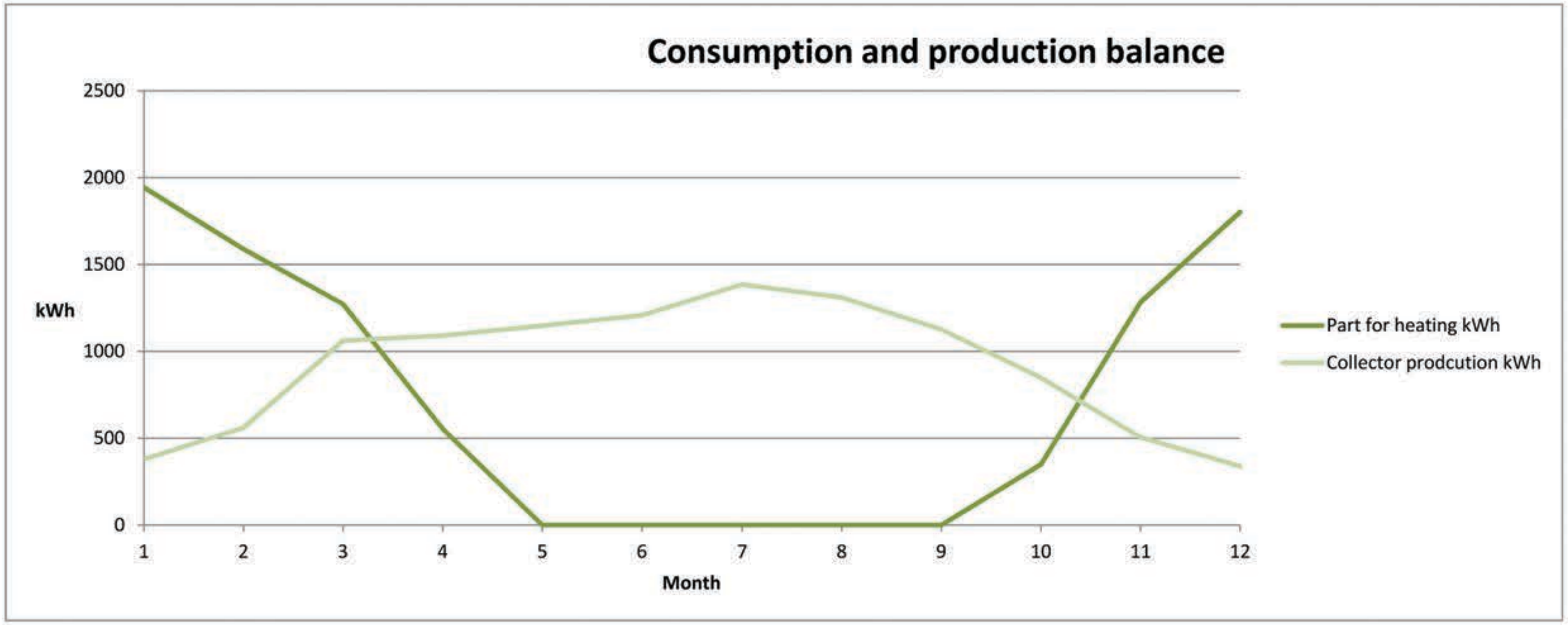
Month	January	February	March	April	May	June	July	August	September	October	November	December	
Heating	1943	1589	1272	554	0	0	0	0	0	349	1283	1802	8793
Total	1943	1589	1272	554	0	0	0	0	0	349	1283	1802	8793
Part from the total	22,08%	18,06%	14,45%	6,30%	0,00%	0,00%	0,00%	0,00%	0,00%	3,97%	14,58%	20,48%	

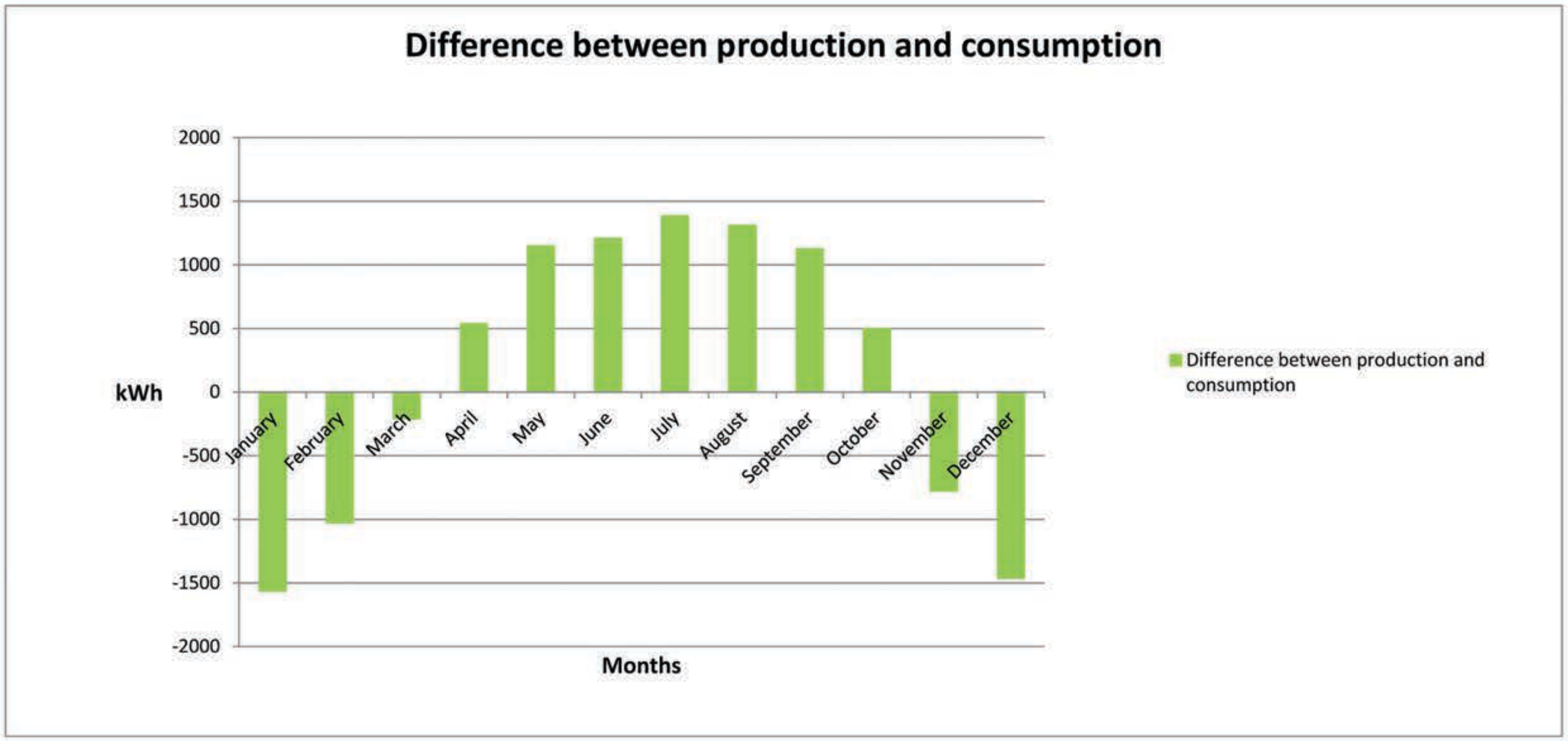
Production from the solar collectors

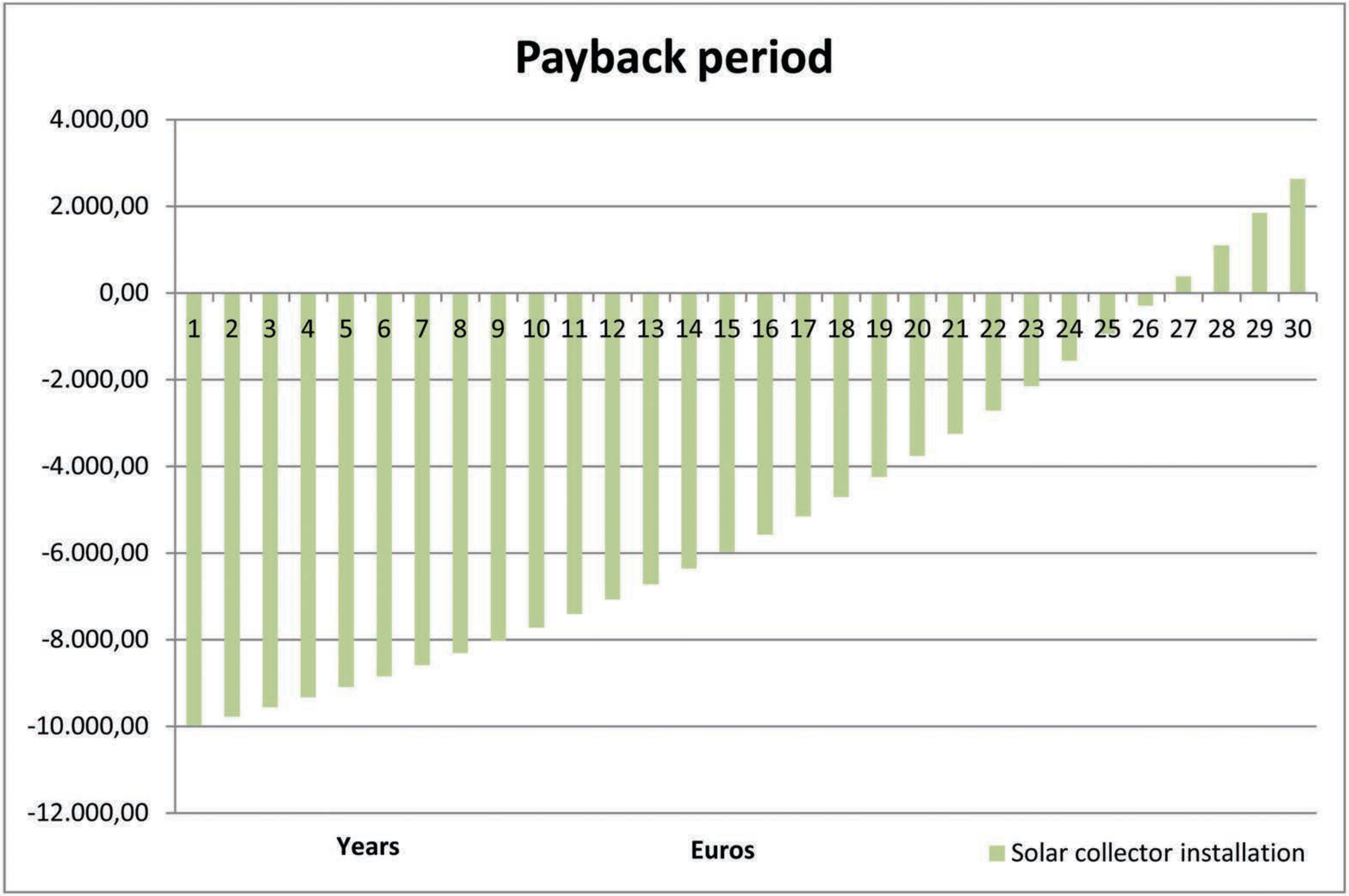
Area of installed collectors	11	м2											
COP of installed collectors	54%	59%	67%	64%	60%	60%	62%	59%	64%	58%	53%	51%	
Month	January	February	March	April	May	June	July	August	September	October	November	December	Сума
Monthly solar radiation kWh/m2	63,9	86,5	144	155	174	183	203	202	160	133	86,7	60,3	1651,4
Collector prodcution kWh	380	561	1061	1091	1148	1208	1384	1311	1126	849	505	338	10964
Difference between production and consumption	-1563,6	-1027,5	-210,7	537,1	1148,4	1207,8	1384,5	1311,0	1126,4	499,4	-777,9	-1464,1	
Difference between production and consumption	1563,6	1027,5	210,7	-537,1	-1148,4	-1207,8	-1384,5	-1311,0	-1126,4	-499,4	777,9	1464,1	
Difference between production and consumption	-1564	-1028	-211	537	1148	1208	1384	1311	1126	499	-778	-1464	

Result

Needed for accummulation	5044
Part from the total need	57,32%
Available for accummulation	7215
Losses from fittings and heat exchangers	10,00%
Losses in the accummulator	10,00%
Useful accummulation	5844
Part from the total need	66,41%


Consumption and production balance
2500
2000
1500
1000
500
0
kWh
1
2
3
4
5
6
7
8
9
10
11
12
Month
Part for heating kWh
Collector prodcution kWh


Difference between production and consumption
2000
1500
1000
500
0
-500
-1000
-1500
-2000
kWh
January
February
March
April
May
June
July
August
September
October
November
December
Months
Difference between production and consumption



Payback period
4.000,00
2.000,00
0,00
-2.000,00
-4.000,00
-6.000,00
-8.000,00
-10.000,00
-12.000,00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Years
Euros
Solar collector installation

APPENDIX :
PVGIS estimates of solar electricity generation

Performance of Grid-connected PV

PVGIS estimates of solar electricity generation

Location: 44°48'53" North, 20°25'46" East, Elevation: 77 m a.s.l.,
Solar radiation database used: PVGIS-CMSAF

Nominal power of the PV system: 5.0 kW (crystalline silicon)
Estimated losses due to temperature and low irradiance: 9.0% (using local ambient temperature)
Estimated loss due to angular reflectance effects: 4.0%
Other losses (cables, inverter etc.): 14.0%
Combined PV system losses: 24.9%

	Fixed system: inclination=0 deg., orientation=0 deg.			
Month	**Ed**	**Em**	**Hd**	**Hm**
Jan	4.72	146	1.20	37.3
Feb	7.84	219	1.96	54.8
Mar	14.50	449	3.69	114
Apr	18.70	561	4.90	147
May	21.70	674	5.84	181
Jun	23.30	700	6.39	192
Jul	23.80	737	6.57	204
Aug	21.00	650	5.76	179
Sep	15.30	460	4.09	123
Oct	10.80	335	2.84	88.2
Nov	6.07	182	1.60	48.0
Dec	3.78	117	0.98	30.5
Year	14.30	436	3.83	117
Total for year		5230		1400

Ed: Average daily electricity production from the given system (kWh)

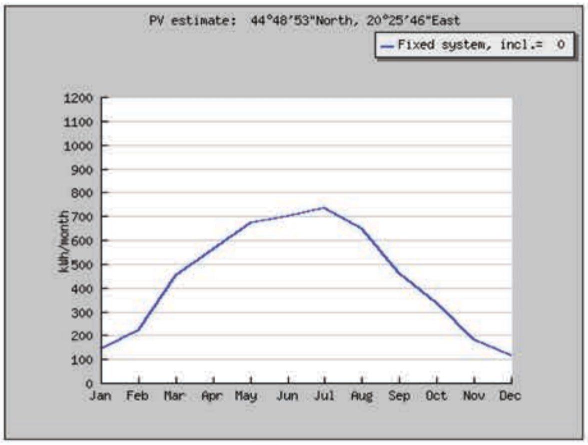
Em: Average monthly electricity production from the given system (kWh)

Hd: Average daily sum of global irradiation per square meter received by the modules of the given system (kWh/m2)

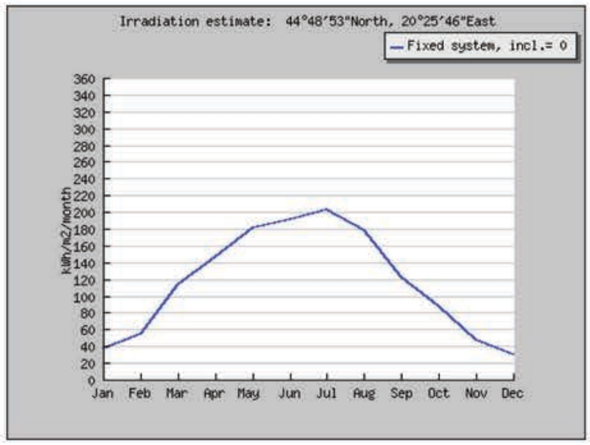
Hm: Average sum of global irradiation per square meter received by the modules of the given system (kWh/m2)

Photovoltaic Geographical Information System

European Commission
Joint Research Centre
Ispra, Italy



Monthly energy output from fixed-angle PV system



Monthly in-plane irradiation for fixed angle

Performance of Grid-connected PV

PVGIS estimates of solar electricity generation

Location: 44°48'53" North, 20°25'46" East, Elevation: 77 m a.s.l.,
Solar radiation database used: PVGIS-CMSAF

Nominal power of the PV system: 5.0 kW (crystalline silicon)
Estimated losses due to temperature and low irradiance: 10.1% (using local ambient temperature)
Estimated loss due to angular reflectance effects: 2.9%
Other losses (cables, inverter etc.): 14.0%
Combined PV system losses: 25.0%

	Fixed system: inclination=30 deg., orientation=0 deg.			
Month	**Ed**	**Em**	**Hd**	**Hm**
Jan	7.33	227	1.78	55.1
Feb	10.90	305	2.68	75.2
Mar	17.80	553	4.59	142
Apr	20.40	612	5.45	163
May	21.70	673	5.92	184
Jun	22.30	669	6.20	186
Jul	23.20	718	6.50	202
Aug	22.30	692	6.24	193
Sep	18.40	552	4.97	149
Oct	15.20	471	3.98	123
Nov	9.90	297	2.50	75.0
Dec	6.10	189	1.48	46.0
Year	16.30	496	4.37	133
Total for year		5960		1590

Ed: Average daily electricity production from the given system (kWh)

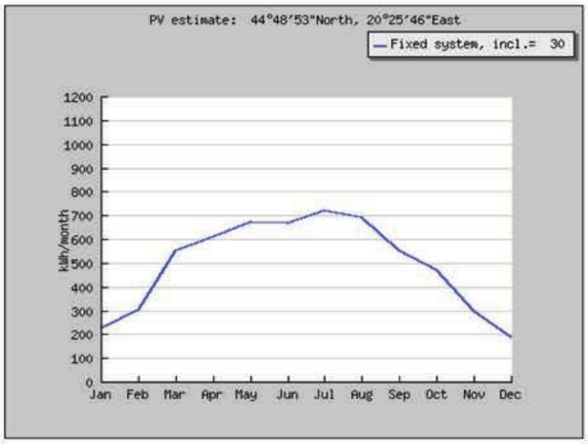
Em: Average monthly electricity production from the given system (kWh)

Hd: Average daily sum of global irradiation per square meter received by the modules of the given system (kWh/m2)

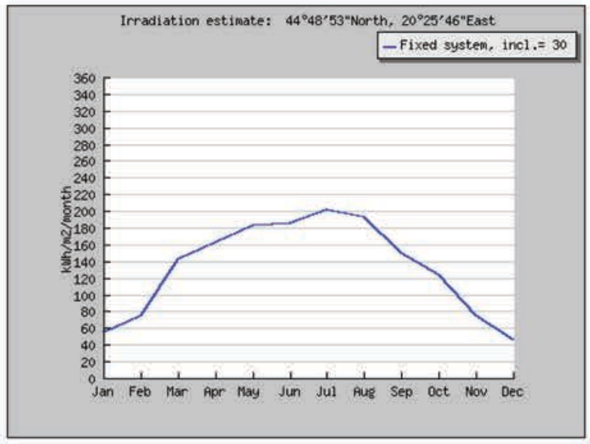
Hm: Average sum of global irradiation per square meter received by the modules of the given system (kWh/m2)

Photovoltaic Geographical Information System

European Commission
Joint Research Centre
Ispra, Italy



Monthly energy output from fixed-angle PV system



Monthly in-plane irradiation for fixed angle

APPENDIX

REFURBISHMENT SCENARIOS FOR POST-WAR SOCIAL HOUSING IN EUROPE: STATE OF THE ART

CASE 1: Change of Identity of “Geldershoofd” in Amsterdam – Bijlmermeer

The “Geldershoofd building” Figure 1, a multi storey residential block for 1300 people in 502 dwellings was built in 1965 based on the CIAM (Congrès International d'Architecture Moderne) ideas.(Di Giulio, R., Bozinovski, Z., Verhoef, 2007). The buildings were hundreds of metres long and 10 or more storeys high. The total length of the building is 315 metres and it is sub-divided into 8 sections, each about 40 metres long and with its own stability system. A huge panel system is applied based on the small construction spans from 3 to 5m. Each dwelling had three load bearing walls; two of these were shared with theneighboring tenants and one was placed between. The walls were only 180 mm thick. The floor thickness, which was related to the biggest span of 5 metres, was 170 mm and was later covered with a 50 mm sand-cement layer.

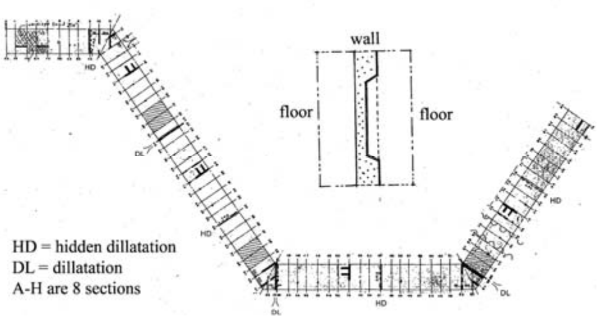


Figure 1: Geldershoofd building: Multi storey residential block

The idea behind the plan for upgrading “Geldershoofd” massive block was to create a number of different types of dwelling within the existing building. The new dwelling types, in combination with a new infrastructure inside and outside the building, provide the setting for the many different types of dwellings. The results obtained are: diversity of residents, buyers or tenants, cheaper or more expensive rents and diversity of dwelling units.

To achieve the desired variety in the building layout it was done the interventions to make new types of dwellings. The strengthening of the foundations, together with the addition of dwellings at the top of one end of the building as a new volume ‘Kophuis’ (Figure 3). The creation of bigger openings and the means to maintain the stability of the structural system was obtained in the volume of ‘Hoge poorthuis’ and finally, the use of cantilevered beams for the extended balconies in ‘Etalagehuis’.

The addition of the ‘Kophuis’ to the existing building means that the end bearing wall has to carry a greater load. Although the concrete wall itself is strong enough, the foundation is not so extra piles have to be driven next to the existing piles. The easiest way to provide the necessary addition strengthening is to add ‘renovation piles’.

The three stories that have to be added to the existing concrete structure of the ‘Gelderse hoofd’ are executed as a steel truss cantilevered over the roof, while the two floors beneath are suspended on this truss. For a statically ideal scheme for the truss see fig. x. However the positioning of such a truss is a source of conflict because people have to pass easily without noticing the bearing structure.

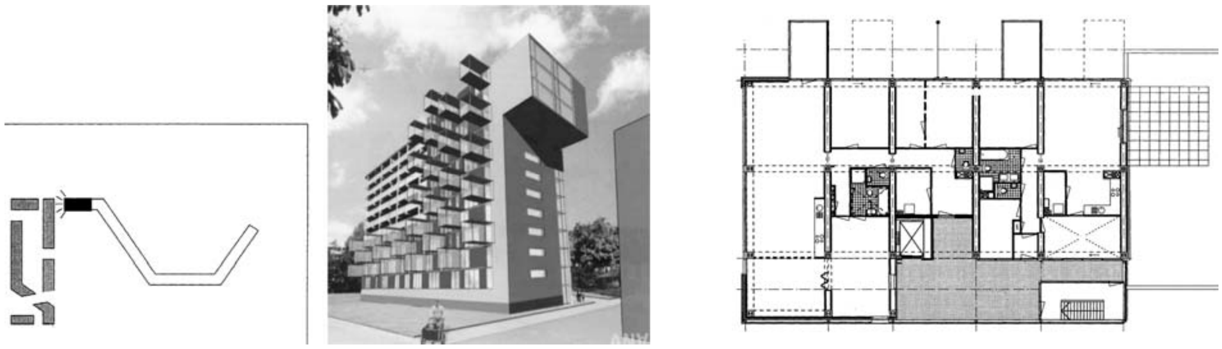


Figure 2: Location of "Kophuis" in "Geldersepoort"; view of "Kophuis"; top floor plan

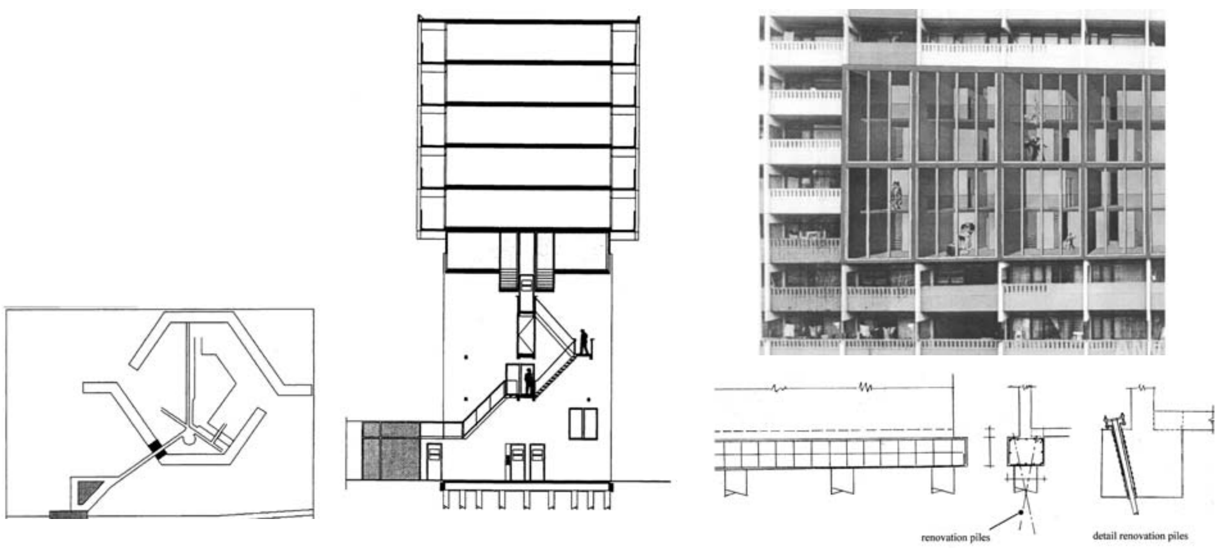


Figure 3: Position ’Hoge Poorthuis’, in ’Gelderse poort’; vertical section through ‘Hoge Poorthuis’; view of the facade of the ‘etalagehuis’ with new balconies.

By adding the balcony areas to the dwellings (Figure 3), which are then covered by a transparent facade, a new space has been added to the dwelling .Prefab concrete balcony elements will to be removed. The cantilevered beams on which a column was suspended to connect the concrete balustrade have to be changed. It is also necessary to remove the columns, with exception of those at each end of the ‘Etalagehuis’. The existing floor area must be increased to span the space between the cantilevered beams. As is the case throughout the building, the total thickness of the floor will be 170 mm concrete, plus a 50 mm sand-cement layer for leveling.

➢ CASE 2: WBS 70 huge panel systems: The Franz-Stenzer Building Block

In the post war construction until the fall of the wall in 1990, about 3 million residential units were built in the former GDR. 27,5 % was constructed using the WBS 70 large panel system (Figure 4). A redesign has been made for a large building block containing 580 dwellings. The redesign consists of the complete interior redesign as well as a totally new façade. The interventions are designed as a catalog to be used in transformations of other WBS 70 building blocks.[1]

The project is aimed at two main targets, one in the field of architecture, one in the field of building technology:

- To make a redesign for a WBS 70 residential building of eleven stories in such a way that the diversity of floor plans increases. The ultimate goal is to make a combination of dwellings, suitable for all ages and all sections of the population.
- To define the possibilities and impossibilities of the building system WBS 70.

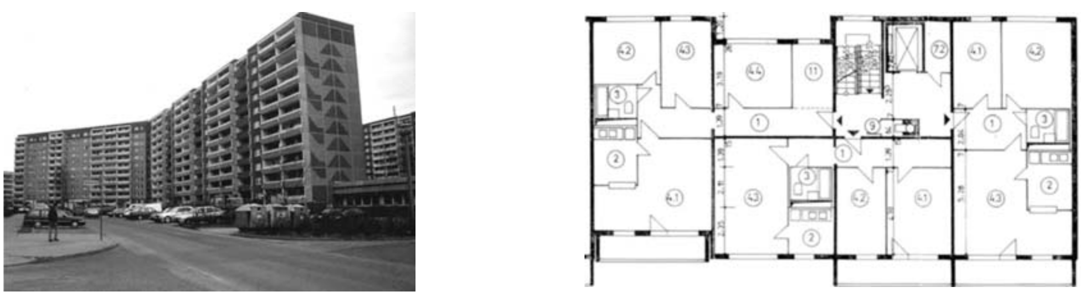


Figure 4: WBS 70 building model (left), Typical WBS 70 floor plan

WBS 70 system is a fully integrated building system. It contains bearing elements, façade elements, internal finishing, staircases, bathrooms, etc. The buildings are recognized by their rigid pattern of heavy weight concrete loggias. Figure 4 shows a typical floor of a WBS 70 building with three housing units arranged around a hallway, which contains a staircase, an elevator and a garbage shoot. Recognizable are the wide loggias (span: 6 m) and the uniform, prefabricated bathrooms.

The research was aimed at 5 points:

a) The possibilities to add building parts to the façade (balconies, winter gardens, galleries, etc.)
b) The possibilities to extend the use of the roof of the building blocks.
c) The possibilities of creating breakthroughs in the building
d) The possibilities of changing the entrances
e) The possibilities of adding a new façade

---

[1] Improving the Quality of Existing Urban Building Envelopes - Structures. R. di Giulio, Z. Bozinovski, L.G.W. Verhoef (eds.) IOS Press, 2007.

f) Horizontal extension of the building.

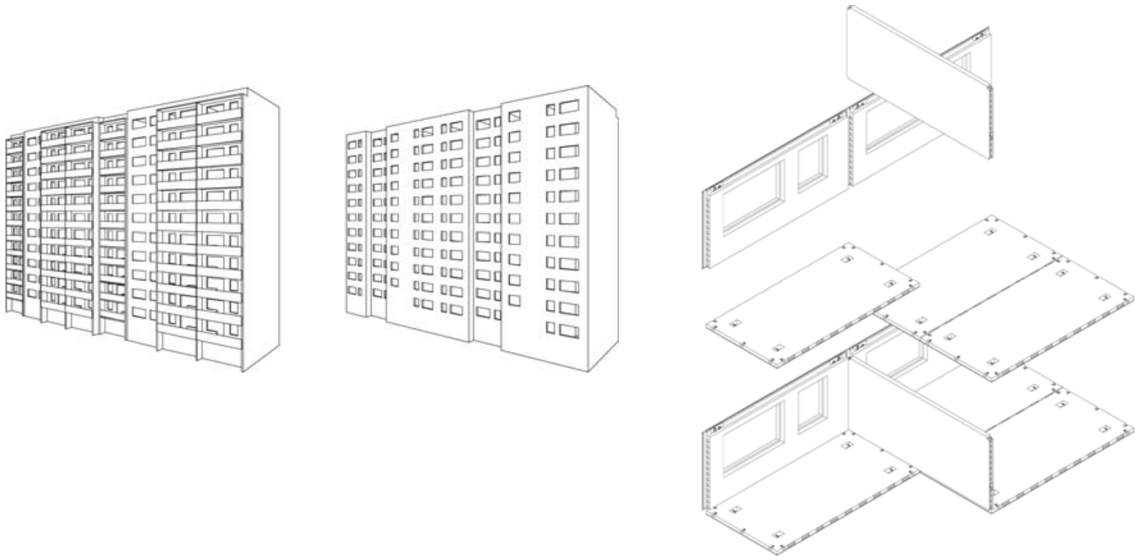


Figure 5: WBS 70 building model : Load-bearing components

Figure 6 show two different principles to horizontally extend a building. The first principle is meant to be a lightweight steel construction. A construction like this can be connected to the WBS-70 construction by steel consoles and bonded anchors. With this construction method it’s possible to make winter gardens, balconies and galleries with a maximum with of 2 m.

Figure 8 shows the second principle. This principle is aimed at making heavy weight extensions. This construction method makes use of the concrete walls and floors of the WBS-70 system to transfer the load to the foundation. When one floor is extend over 3 m., about 15 bonded anchors in the upper floor are necessary to transfer the load to the existing construction (Verhoef1999, Hordijk 1999)

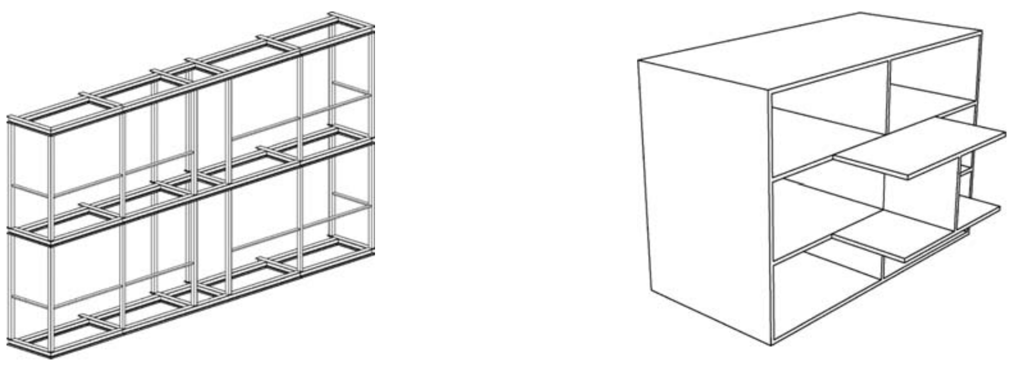


Figure 6: Steel construction for four winter gardens (left); Principle of a concrete extension (right)

- **Intervention in the façade**

In Quist (2003) the varieties have been worked out in detail. A catalog has been designed which offers different solutions for different needs. The removal of the parapet wall which creates the possibilities to introduce a balcony with easy access by sliding glass doors. In the past an investigation was carried out by IEMB [2] to find out whether it's possible to apply a new façade construction to the existing façade. It carried out to be possible to apply a new cladding up to 200 kg/m².

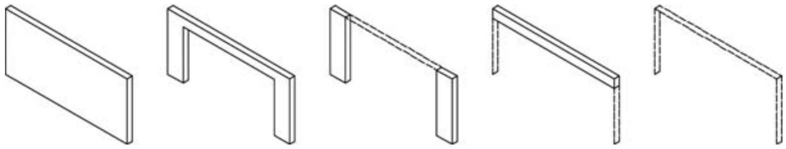


Figure 7: Execution varieties of breakthroughs in load-bearing facade elements: a) existing, b) easiest option, removing parapet, c) removing parapet and "beam", d) removing "columns", e) removing complete element.

- **Internal transformations**

Changing the limits of the dwelling units is possible. Two housing units can be combined by (partly) removing load bearing common wall. The techniques are comparable with interventions in the façade. A second possibility is to create maisonnettes by (partly) removing floor elements (Figure 8). This technical intervention offers architectonic possibilities to create double high spaces and it offers differentiation in the façade. Also sound problems can be reduces by vertically combining housing units.

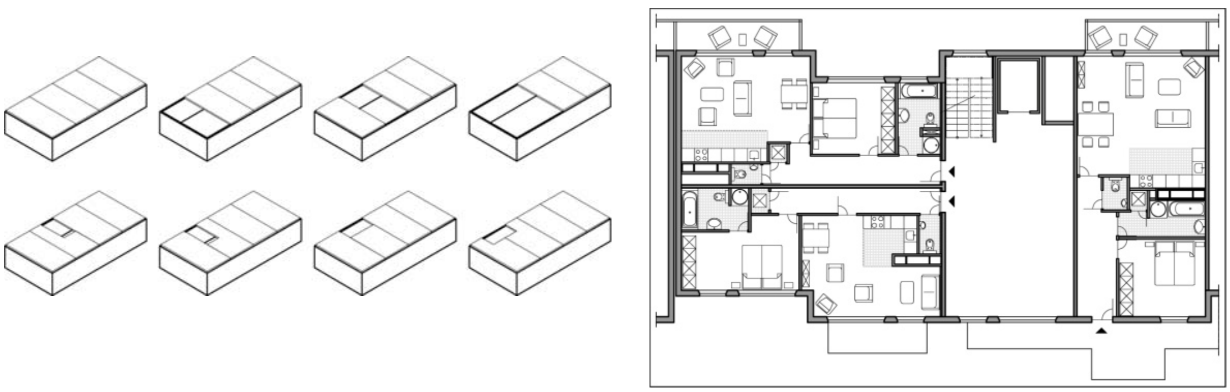


Figure 8: Removing (parts of) floor elements (left); New floor plans (right)

Figure 8 left shows some possible new floor plan. In Quist (2003)[3] a lot of new apartment types have been introduces to compose a "new" building in an old skeleton.

➢ CASE 3: Adaptations and Improvements on a Refugee Estate in Cyprus

Most of the buildings of the refugee estate needed a different type of improvement, depending on the condition. The common types of renovation were:

---

[2] www.iemb.de

[3] Quist, W.J.; Afstudeerrapport: Een toekomst voor WBS-70 – Een herontwerp voor 11-laagse prefabbetonnen portiekflats in Marzahn (Ooost-Berlijn); 2003

- Repair of damaged structures (without upgrading their structural capacity).
- Repair and strengthening of damaged structures (including upgrading of the seismic capacity of the building and foundations).
- Additions of structural elements.
- Removal of unnecessary loads.

Figure 9: During the renovation and after the completion of the works

The columns of the building have overpass the maximum bearing capacity codes due to: i) poor construction materials, ii) more loads than those they could afford. The solution adopted was the upgrading of the structure, by increasing its load-bearing resistance (Figure 10).

Figure 10: Reinforcement of an inside column (left), adding of a new column (right)

The construction safety was the main issue of this case study. The vast majority of the renovations were related to the construction safety and the stability against earthquake actions. A lot of unnecessary loads, like surrounding walls on top of the buildings or balconies, were removed. Only conventional techniques were adopted and no efforts for use of FRPs or other modern methods were made.

➢ CASE 4: Transformation process on the building structure for creating flexibility in dwellings in multi storey buildings[4]

Multi-family residential units in the Netherlands built during the period 1950-1980 (Figure 11) have been renewed for more functional flexibility. Rigid concrete frame has been submitted to transformation process for more flexible dwellings layout. The skeleton consists of cast in situ concrete floors and walls. The floors above the ground floor were constructed at the same time as the walls by using narrow tunnel shuttering. The widest floor spans are only 4 meters. The cantilever beams for galleries and balconies are made of prefabricated concrete, mounted in or on the tunnel formwork and attached to the bearing construction by reinforcements. The concrete walls provide the stability of the building in both transverse and longitudinal directions. This load-bearing system doesn't support the adaptation of the dwelling units. The small span of the load-bearing structure is boundary condition for functional transformations. With the widening of the openings, firstly, a much wider view can be obtained; secondly the obtained dwelling surface is larger and more flexible.

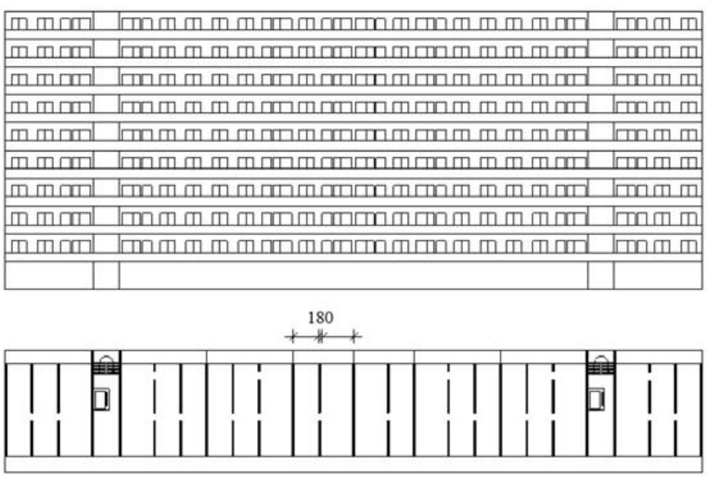


Figure 11: Existing situation of the multi storey 'Hoogoord' block

- **Enlarging door openings in the bearing walls**

One of the principal goals was flexibility of function within the dwelling itself. To reach a more flexible situation the solutions were found by creating wider openings in bearing walls than the door openings that

---

[4] L.G.W. Verhoef, Faculty of Architecture, Delft University of Technology, The Netherlands; N. Hendriks, H. van Nunen & R. Laurs, Faculty of Architecture, Eindhoven University of Technology, The Netherlands

merely provide access from one room to another. In principal three rehabilitation strategies has been applied:

- Openings are enlarged enough to reach ‘flexibility’ (Figure 12);
- Openings can be enlarged, but the addition of columns still ensures adequate support;
- The entire bearing wall is removed and replaced by a rigid frame.

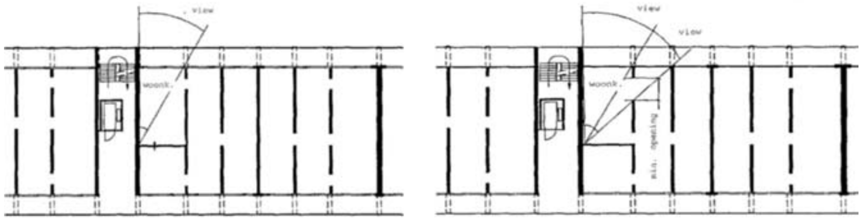


Figure 12: Original plan with limited view to the outside (left); Proposal for extended view and opening of the division wall (right)

If every second floor is opened the intervention doesn't affect the structure as a whole. In principal, the mechanical system stays more or less the same because the stiffness of the wall in the area of the openings does not change. Moreover, the shear forces on the end column do not increase.

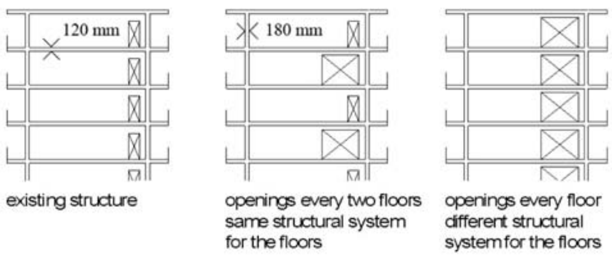


Figure 13: Possible interventions: a) existing structure; b) openings every two floors c)opening every floor

Figure 14: Positioning and connecting of rigid steel frame (left); Removing the bearing wall (right)

In the Figure 14 an entire bearing wall was removed and replaced by a rigid steel frame. The steel frame works as a load-bearing wall in the building structure and is completely flexible for further division of the dwelling space.

One of the four bearing walls was demolished for the test. The consequence of the removal of such a bearing concrete wall is that also parts of the floor slabs have to be demolished and the parts of the belonging façade. After the installation of the new steel supported frame, the missing part of the floor has to be connected to the steel frame by installing in situ concrete with rebars. On the Figure 15 is analyzed the possibility for redesign of the floor plan without total demolition of the massive bearing wall, but only one part.

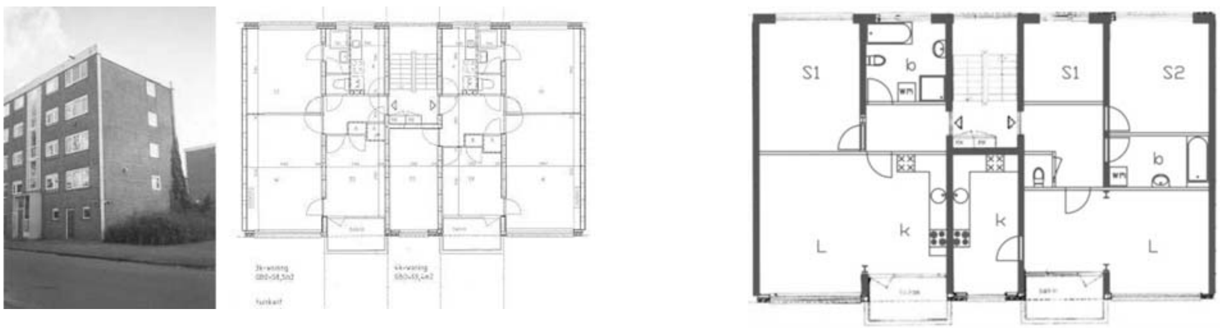


Figure 15: Existing floor plan (left); Alternative floor plan that shows that removing only one part of the bearing wall (right).

➢ CASE 5: Rehabilitation of the building by regeneration process of the building envelope

"Square Vitruve" is social housing building in co-ownership built on a concrete slab. Along with the construction of the tramway, the ongoing Major Urban Renovation Project for the Saint Blaise neighborhood included the rehabilitation of the building. The major rehabilitation of this degraded building containing 56 social housing units was carried out while it was in use in a highly complex urban, technical and statutory. Rehabilitation of the whole building was done by rehabilitation strategies of the building envelope.

Figure 16: Building model before and after façade refurbishment

Figure 17: System for new industrialized façade system

On the existing façade the balconies had been added. Integrated rehabilitation strategies were put together into design of the new integrated system for the building vertical skin structure. A kit of parts systems is used to find different purposes for the new skin addition and assembled. This new skin was installed without putting machinery on the concrete slab and using no cranes or pods, and without dislocation of the tenants (Figure 18). The balconies are suspended from the roof, and all the materials and technical solutions have been designed to avoid overloading of the existing structure and disrupting residents' daily life. Finally this kind of building rehabilitation process can be define as a total building upgrading by building envelope regeneration process.

Figure 18: Building façade during and after rehabilitation

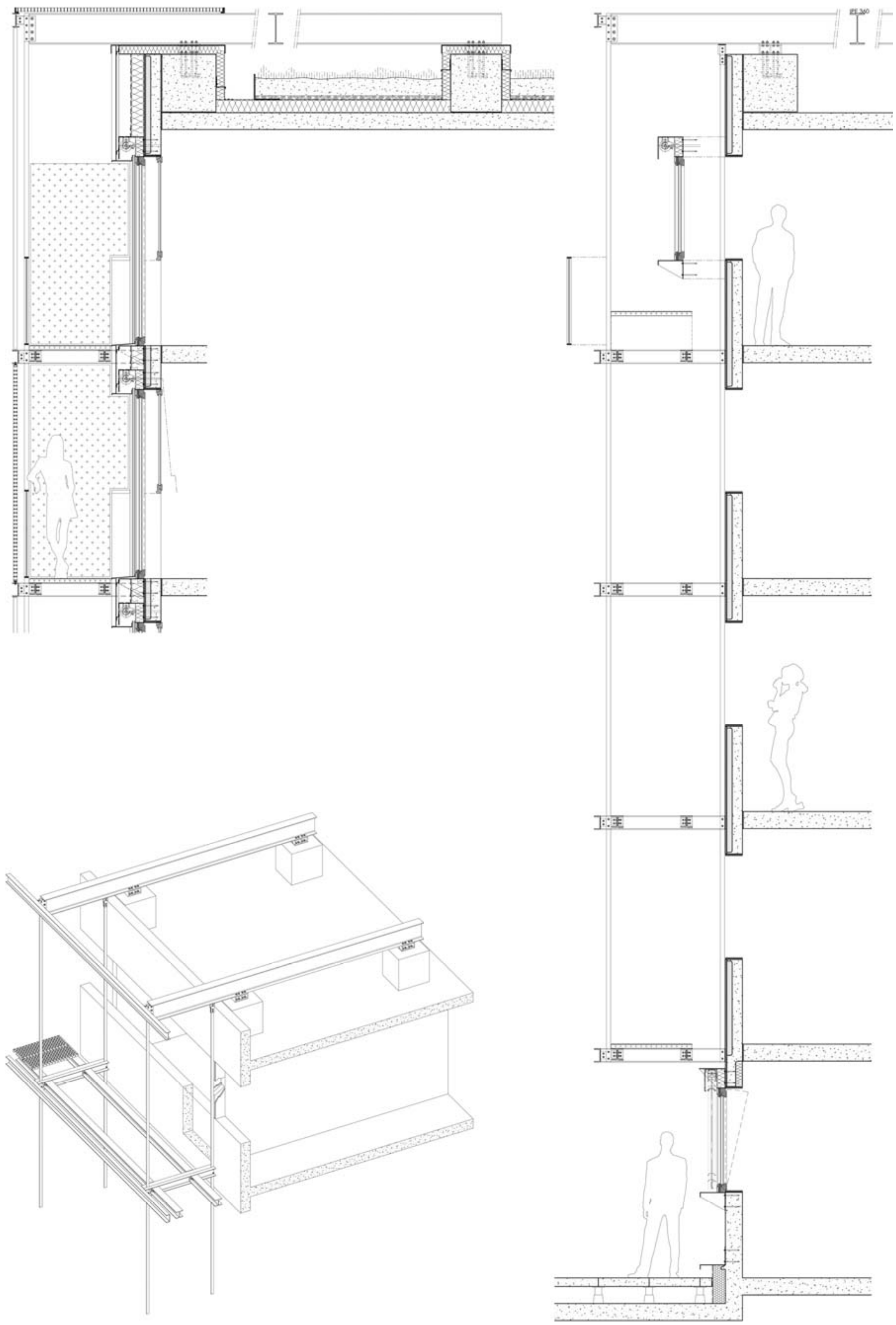


Figure 19: Detail of the new façade construction hanging from the roof top

➢ CASE 6: Restoration of the 'Planeten flats' in Helmond[5]

'Planeten flats' is residential area of 7 multi-storey residential blocks. Such blocks of gallery flats built according to the 'Neduco' system are massive concrete panel structure. The block of flats is a composite concrete structure. Walls and floors were constructed from in situ concrete. The cantilevered beams were prefabricated and placed on the system formwork (Figure 20). The beams were connected to the walls after the concrete has been poured into the formwork of the wall, and had hardened. This type of structure is known as the NEDUCO system.

During the rehabilitation process the building is divided into three distinct horizontal layers, with new spacious entrance hall and winter garden with a multipurpose function. Different interventions on the building structure have been undertaken. It was necessary to make the hole inside the concrete panel structure. These include different transformation on the structural elements that are partially standing and partially suspended and the method used to remove bearing walls and replace them by prefabricated concrete columns to bear the steel beams as supports for the bearing walls of above floors.

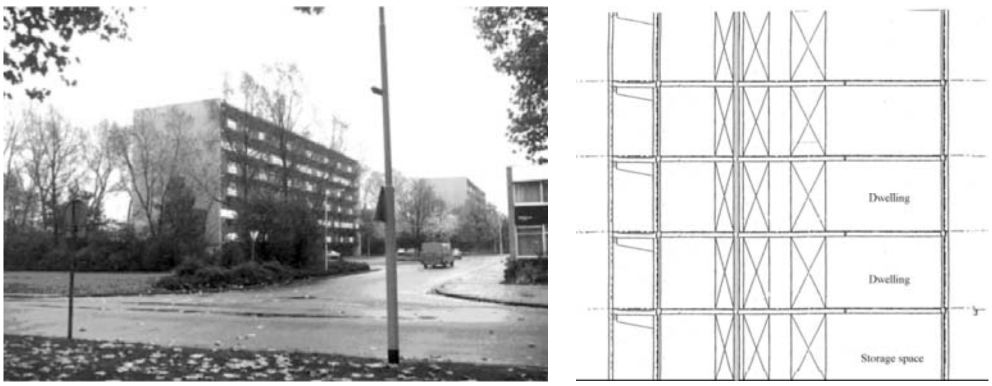


Figure 20: a) Existing building: elevation; b) cross section of the load-bearing structure

The main transformations involved adaptations of the load- bearing structure to incorporate the desired qualities of dwelling units and building envelope, including:

i. the creation of a new entrance space with a winter garden;
ii. the enlargement of the balconies and adding new balconies;
iii. the provision of closed access gallery on the floors designed for elderly residents.

To create space for the entrance hall and winter garden, bearing walls were removed over the lower three floors, while the upper floors with dwellings had to remain undisturbed. The bearing wall above that

---

[5] Improving the Quality of Existing Urban Building Envelopes - Structures. R. di Giulio, Z. Bozinovski, L.G.W. Verhoef (eds.) IOS Press, 2007.

level are supported by four prefabricated concrete columns ø 400 mm and a steel beam HE340B on top of the four columns and under the in situ concrete wall that extended from the fourth floor to the roof (fig. x). Tee steel beams under the concrete wall was necessary because the bearing wall was not the continue slab but a slab with large openings (Figure 21).

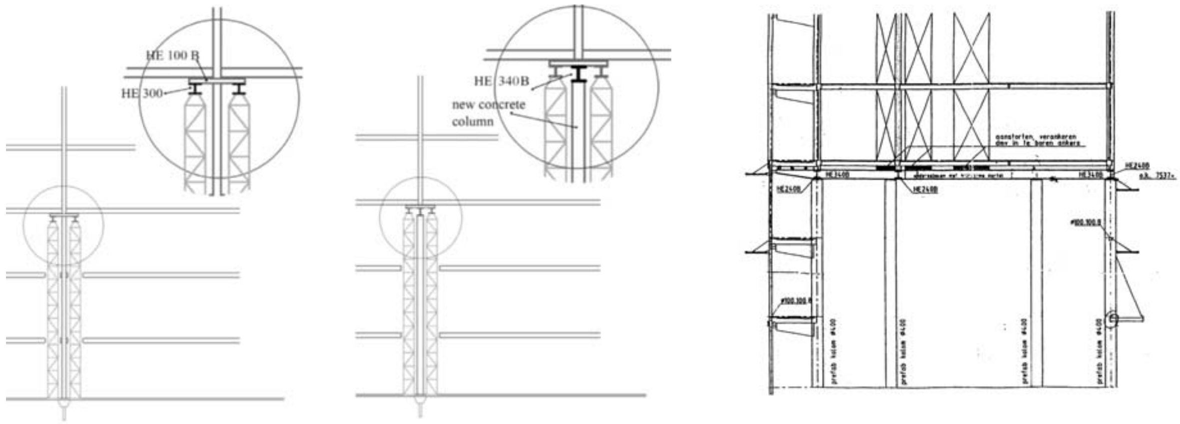


Figure 21: Mounting final structure of concrete columns with HE340B on top (Temporarily support structure); Assembling of the bearing structure of the winter garden (right)

For the closed access gallery new concrete façade elements were added. The concrete facade elements are supported by vertical concrete slabs. The slabs are supported by a new extension of the foundation supported by concrete piles. The middle parts of the concrete facade elements are executed as a system that carries the load up to the roof by tensile tubes 80.80.4 mm. On the roof itself are trusses to connect these forces to the bearing concrete walls (Figure 22). The last part of the concrete facade is supported by cantilevered steel beams over new columns above the winter garden.

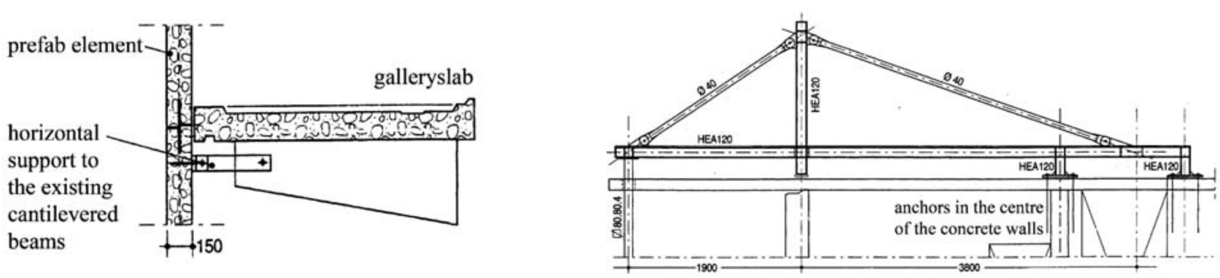


Figure 22: Connecting prefab façade elements to cantilevered beam; New concrete façade elements carried by tensile tubes to the roof structure

For the enlarging of the balconies the vertical concrete bearing slabs are used as the most important system. The extensions of the balconies have been constructed as concrete slabs surrounded by UNP 200 for the outer sides and L 150.75.12 as connections to the existing ends of the concrete balconies. On one side the UNP is connected to the bearing construction by chemical anchors and on the other side is connected to a framework made from tubes 120.60.4 mm which are also connected to the bearing walls by chemical anchors.

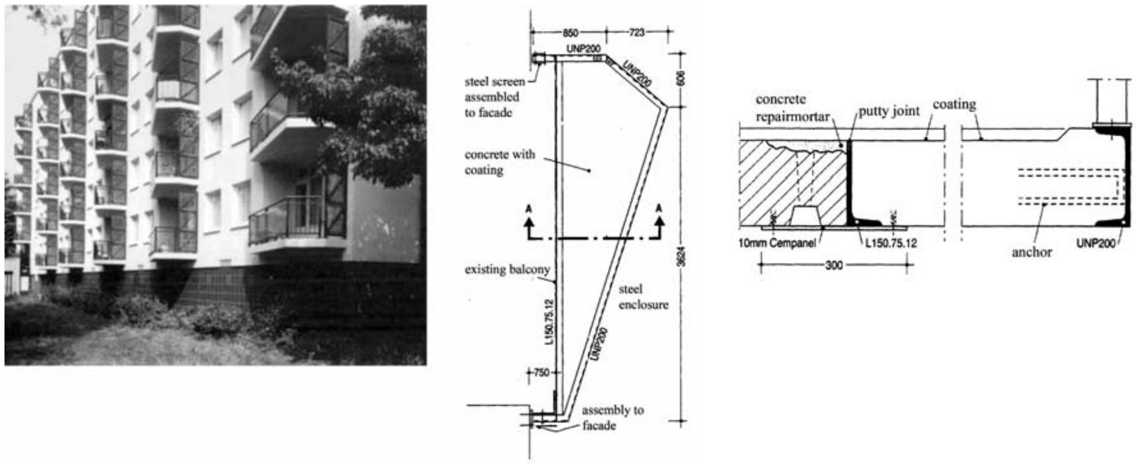


Figure 23: View of the planeten flat with balconie ; top view of the balcony; connection with the existing structure

The dwellings space was enraged by connecting two bedrooms to make one. Also it was enlarged the shower cell to provide a complete bathroom and increase both safety and comfort.

Figure 24: Building model before and after façade refurbishment

➢ CASE 7: Rebuilding Modern Housing for Increased Sustainability[6]

The residential area Markbacken was built 1958-1963 in Örebro, a city of about 125 000 inhabitants in mid-Sweden. The developer was the municipal housing company Örebrobostäder AB (ÖBO), still the owner of the area. In all, 1194 flats, with 2-bedroom flats, were built in 3-4-storey slab blocks - U-formed blocks.

---

[6] Sonja Vidén School of Architecture, Royal Institute of Technology, Stockholm, Sweden: Improving the Quality of Existing Urban Building Envelopes - Structures. R. di Giulio, Z. Bozinovski, L.G.W. Verhoef (eds.) IOS Press, 2007. © 2007 IOS Press and the Authors. All rights reserved.

The structure of the buildings is the “book-shelf”-framework of site cast concrete floor structure and transverse inner walls and gable walls. In some buildings there are also load-bearing core walls, and in several parts of the bottom floors concrete pillars are taking loads from the construction above. Gas concrete panels were used for light (not bearing) inner walls. The external walls of the bottom floors were all plastered gas concrete masonry. The external walls of the upper floors were constructed in various ways, with various materials: gas concrete masonry outside all staircases and bathrooms, otherwise prefabricated gas concrete panels with a mineral wool core, or wooden curtain walls with mineral wool covered by wind breaking asbestos panels. The different kinds of external wall constructions of the upper floors were all covered by asbestos cement facade panels on wooden joists. Main problems in the first rebuilding programme had been notified:

- Lack of lift; poor accessibility for people with disabilities;
- Small balconies;
- Inappropriate distribution of flat size;

The main actions concerning structural transformaitions were:

- Installation of lifts in several staircases;
- Enlarging balconies and adding new balconies in special sites.
- Merging flats in bottom floor and first floor for duplex.

Different solution to install lift had been applied. A more frequently used solution was to build new stairs in connection with the existing stairwell, where the flights of stairs were replaced by a lift and a passage. The lift has doors in both ends. The additions to the old buildings, for the new stairways, were designed differently, thus adding more variation to the facades. Still another solution, used in a later stage, was to install a lift in an extension of the stairwell, and replacing the original two flight stair with a single-flight stair (Figure 25).

Figure 25: Entrance floor after installation of lift in extended staircases (left). The additions of the new

Figure 26: Construction of the balcony extension

- **Enlarging balconies**

The additional balcony slab is made by two steel bars, fastened to the old balcony slab (Figure 26). Some small balconies at the corners of buildings were extended around the corner, and given new, rounded forms. A few totally new, rounded balconies were also added. In these cases new, prefabricated concrete structures replaced the old ones. The new balcony slabs, and some considerably extended rectangular slabs, were born by slender concrete pillars, founded outside the existing buildings.

- **Merging flats into duplex**

19 bigger flats were created by adding certain small flats in the bottom floors to flats above. A hole was cut in the concrete floor structure for an internal, prefabricated wooden stair. All those flats got direct access to a new, private terrace at ground level. The main entrances to the flats were placed there.

Figure 27: Transformations for the dwellings

Some of the narrow passages were kept, but renovated with new, brighter surface layers and new lighting. New supporting pillars were installed to support the above floors where the new passages had been obtained. The insulation of the floor structures above was improved, with some difficulties, since the height of the passages already was reduced by crossing pipes (see photos below). Other passages were also widened and given a softer form. The bearing pillars in the bottom floor made this possible without interventions in the main structure (Figure 28).

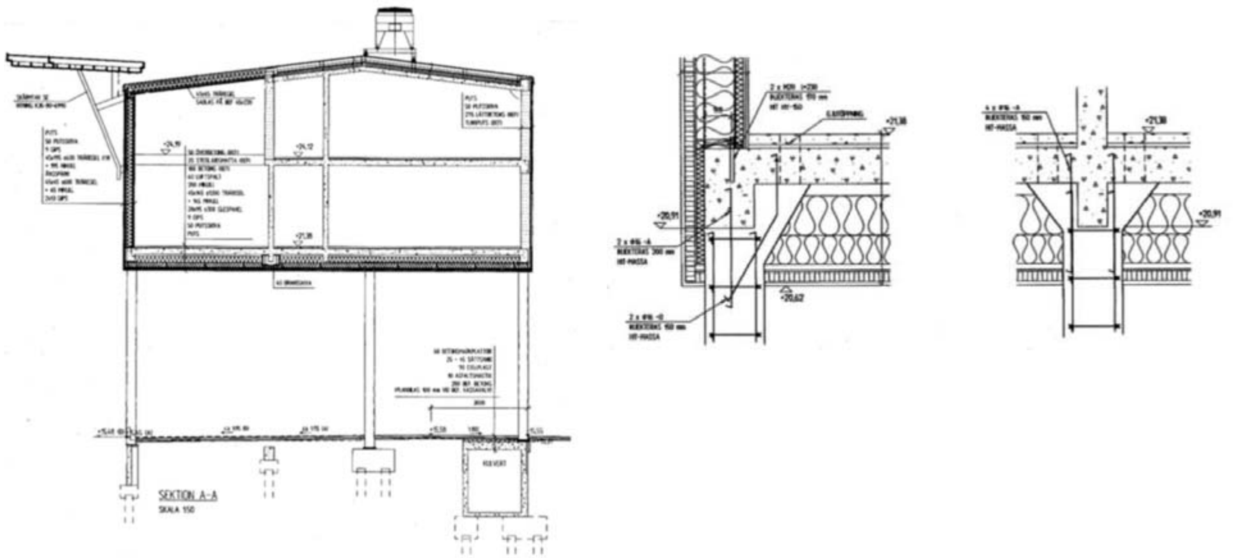


Figure 28: The section and the details show the new floor and wall structures above the portico, with the new insulation layers.

➢ CASE 8: Roof top extensions with prefabricated light steel elements in Heerstrasse 190-22, Frankfurt , Germany[7]

The existing three-storey block in Praunheim, a district of Frankfurt am Main, is a typical residential development of the 1960'. Prefabricated light steel systems for walls and floors and dry construction process has been applied for the roof extension with 12 new apartments built as part of rehabilitation project (Figure 29). During the main action of building extension the complete set of integrated rehabilitation strategies were applied for total refurbishment of the existing buildings: 1) upgrading of the electric current lines; 2) installation of new electric meter; 3) new doors of flat; 4) renewal of the staircases; 5) fire protection requirements (e.g. fire door in the cellar); 6)new paintings of the facade; 7) adding new balconies; 8) rehabilitation of the existing loggia; 9) water tap in the backyards; 10) renewal of the entrances.

[7] http://www.tsb-ing.de/img/projekte/Heerstrasse/Heerstrasse_Projektheft.pdf

Figure 29: Before and after building rehabilitation

A set of integrated rehabilitation strategies for the refurbishment of the buildings supported rehabilitation of the existing building and new construction of the roof top extensions. Important goal was to allow tenants to stay in their dwellings during refurbishments. Prefabrication and industrialized systems and components and light steel construction supported short construction time and building process independent from atmospheric conditions. Light steel elements have good proportion of bearing capacity to dead load (all measures had to be carried out rigorously in lightweight construction because the load-bearing capacity of the existing structure could not accommodate any additional loads); no fire load in the main construction; resistant to deformation by humidity, easy integration of additional installations and feed -lines, all with high potential of recycling (Di Giulio, R., Bozinovski, Z., Verhoef, 2007).

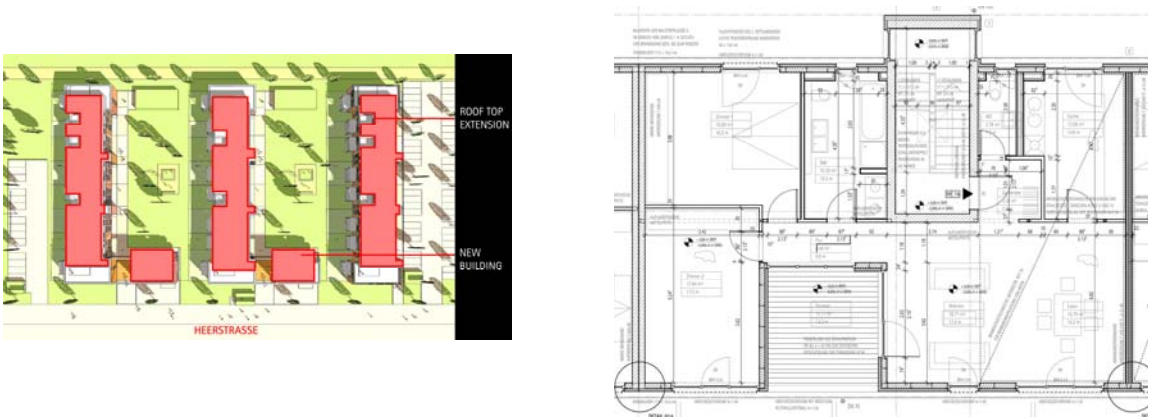
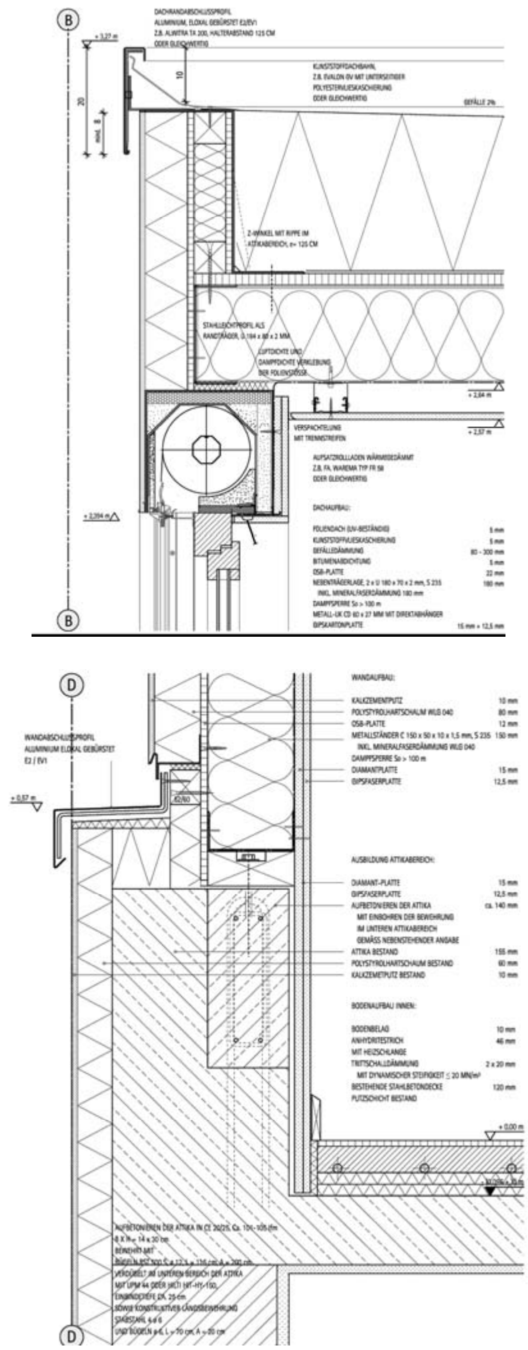


Figure 30: New floor on the top of the existing building

The load-bearing structure for attics of long-span beams thin-walled sheet steel sections enable a flexible plan layout. As this infill development had to be carried out while the other apartments bellow were still occupied, a decision was made to use prefabricated wall and roof elements from the metal studs of 1.5 - 2.0 mm. The use of shot-fired nails enabled easy jointing (Figure 31). It took less than a week to erect the structure of each group of four apartments with a total floor space of approx. 450 m². The external wall elements are provided with insulation, vapor barrier and boarding to both sides (OSB sheets) in the factory.

Figure 31: Attic construction in progress

After positioning the wall and roof elements to form the dwelling units and the horizontal steel beams to span in-between space, the large areas of glazing were installed, a thermal insulation composite system was applied to the outside of the walls. Different construction operations were managed in parallel. The interior fitting-out was carried out at the same time as the thermal insulation works directly after completing the erection of the wall and roof elements. By integrating the insulation into the load-bearing construction of the external walls (insulation in the same plane as the vertical and horizontal metallic studs) and using additional external insulation, U-values in the region of 0.15 - 0.20 W/m²K were achieved.



- Fascia plate to edge of roof, anodised, brushed aluminium, E2/EV1
- Roof construction: UV- resistant sheeting synthetic fleece facing insulation with integral falls, 80-300mm bitumen waterproofing; 22mm OSB, secondary beams S 235, 2No. 180x70x2mm channels 180 mm mineral-fibre insulation, WLG 040 vapor barrier , sd > 100 m metal CD section, 60 x 27 mm, with 40 mm hanger brackets 12.5 mm plasterboard
- Joints in sheeting glued airtight and vapor-tight
- Lime-cement render
- Rigid polystyrene foam, WLG 040, 80 mm
- OSB, 12 mm
- Metal studs, S 235, 150 x 50 x 10 mm, d= 1.5 mm, with mineral-fibre insulation, WLG 040
- Vapor barrier
- Plasterboard with skim coat
- Flashing, anodized, brushed aluminum
- Timber plank, 60 x 150 mm, for mounting prefabricated lightweight steel elements
- Anchors in new parapet section cast in situ, grade C 20/25
- Reinforcement: U-bars cast into existing parapet, longitudinal bars and shear links
- Existing reinforced parapet
- Existing rigid polystyrene foam, 60 mm
- Existing lime-cement render, 10 mm
- Floor construction: wood-block flooring, 45 mm calcium sulphate screed with under floor heating , 2No. 20 mm impact sound insulation
- Existing reinforced concrete roof slab, 120mm

Figure 32: Detail of the new construction: cross section