ROBUST

Renovation Of Buildings Using Steel Technologies

Vertical steel extension – Connection systems

TEST SPECIFICATION

Final Document

CTICM: Ph BEGUIN

11-2009

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1. INTRODUCTION

1.1. *Previous investigations*

1.1.1. Building disposition

The extension shall be builded on a pre-existing building. 50’s to 70’s building construction type for social residential housing are chosen and in this field of construction the self supporting concrete panel walls represent the predominant type of construction technique in France (HLM). Usually the thickness of such a wall is 20 cm plain concrete.

Figure 01 shows the expected, schematic disposition of this type of construction, as existing building and the refurbishing with the steel extension.
Figure 02 shows a plan schematic disposition of the frame. The Width of the building is 12 m and length is 30m. On this sizing we can arrange a schematic frame pattern of 3 types:

- 12 x 6 meter,
- 6 x 6 meter
- Or 6 x 3 meter.

As large the pattern is, as large the sections of the frame will be but also as open the platform will be for partitioning.

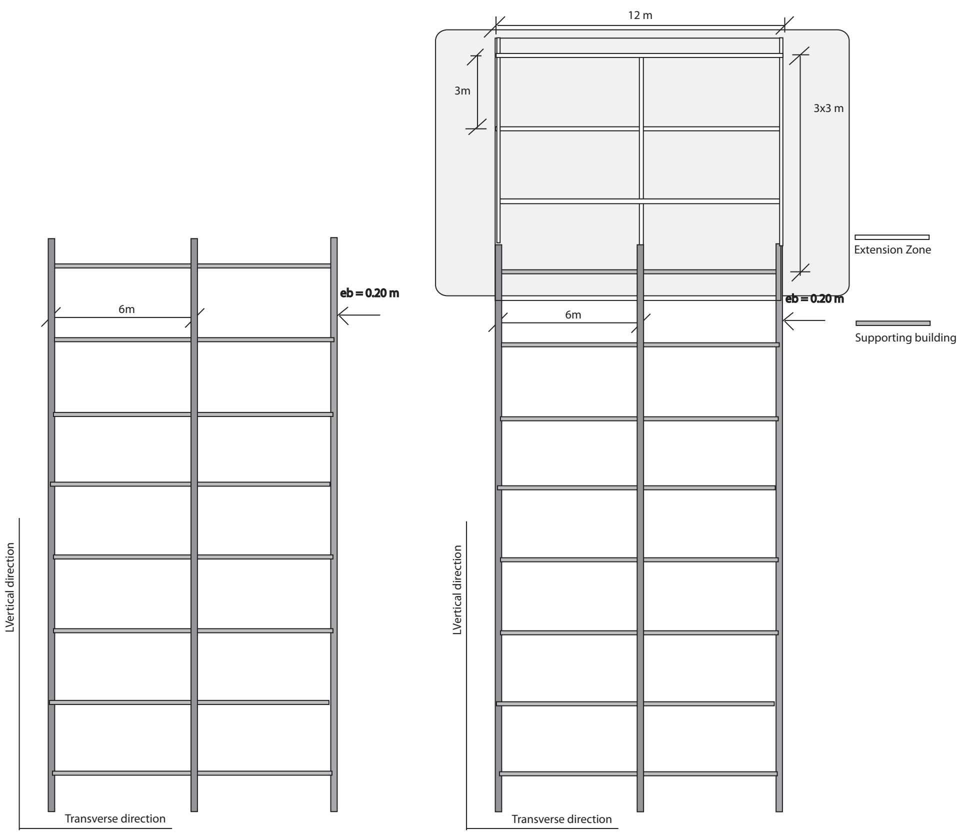


Figure 01: Elevation of schematic disposition of the building: former building and extension

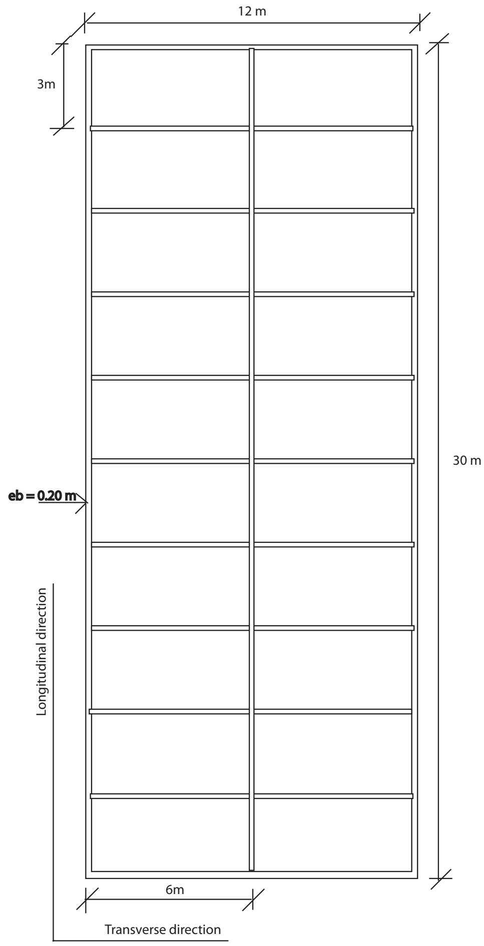


Figure 02: Plan arrangement of the schematic building: 30 m long, 12 m width

2. Extension investigation

2.1. Design

2.1.1. parameters investigation

This material has been discussed during the ROBUS project in Cracow the 6th and 7th July 2009.

We have investigated on sizing but need to have agreement with the other members of the group:

This investigation is only for portal frame. Load for light gauge wall to come from Arcelor.

- Assuming that the existing building is 12 m width at a maximum, 30 m long and that we can vertically extend 1, 2 or 3 levels we have made some assumptions:

- Assumed self weight loading, wind, snow and variables loads as in France and a 15 cm thick concrete slab for each level, (including the first level of the extension as a new extra slab, because the former roof is considered as not able to support a slab.

The following summary of design loads on connections is based on a parametric approach that has combined the design loads as, self weight, live loading, wind, snow, etc and spans in way to scale the range of loadings that affect the connecting devices. Portal frames are supported on the existing building for spans of frame of 12 m or 2 x 6 m (2 portal frames) and transversal span between frame of 3 m and 6 m.

Parametric factors are as follow:

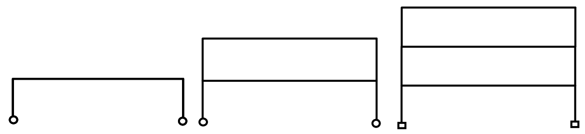
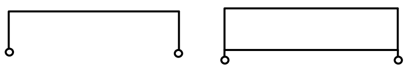
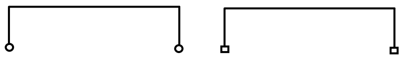
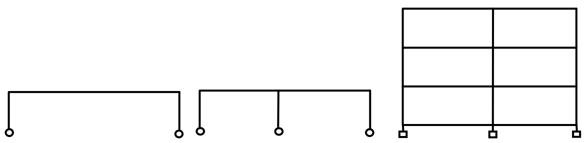
1, 2 or 3 levels extensions (3 cases)	
The roof (assumed to be flat) of the existing building can be used as first floor of the extension or not (60 cm new floor system if not); (2 cases)	
Pinned of rigid connection (2 cases)	
Longitudinal span made of one single frame or two successive frames with one intermediate column (2cases)	

Figure 03: Parametric case studies.

The results are presented in terms of loading actions on the existing frame and design sections of the new steel frame.

Investigations on loading are made on the portal frame option but can be extended to the prefabricated wall. Only the self weight can change leading to connection loading that can vary in a range lower of 30% for the same configuration due to less self weight.

2.1.2. As an example we give some information on a design case

This case is a building of 3 extra levels, 12 meter width made of 2 spans of 6 meter, 30 meter length with transverse span of 3 meter, height of each level is 3 meter including slabs and false ceilings.

The building is located in the suburb of Paris, administrative region of Yvelines (dept 78) at a sea elevation of 60 meter. Wind and snow loadings are automatically generated by the software used (ROBOT).

The building is based on a structural frame made of rolled sections. Other option can include prefabricated wall panels. Information to come from ARCELOR and PRZ but this option has been forgotten (Late October).

The following picture gives a schematic drawing of the extra structure extended on the existing building (3 extra levels). The columns are pinned at each support on the concrete panel wall of the existing building. This is the key problem! as these concrete panel walls are limited in size (20 cm thick) and resistance (concrete from the 60's / 70's in altered condition). We have assumed the concrete will be C16 grade. This grade does not exist anymore in the EC2 code but is representative of the existing conditions.

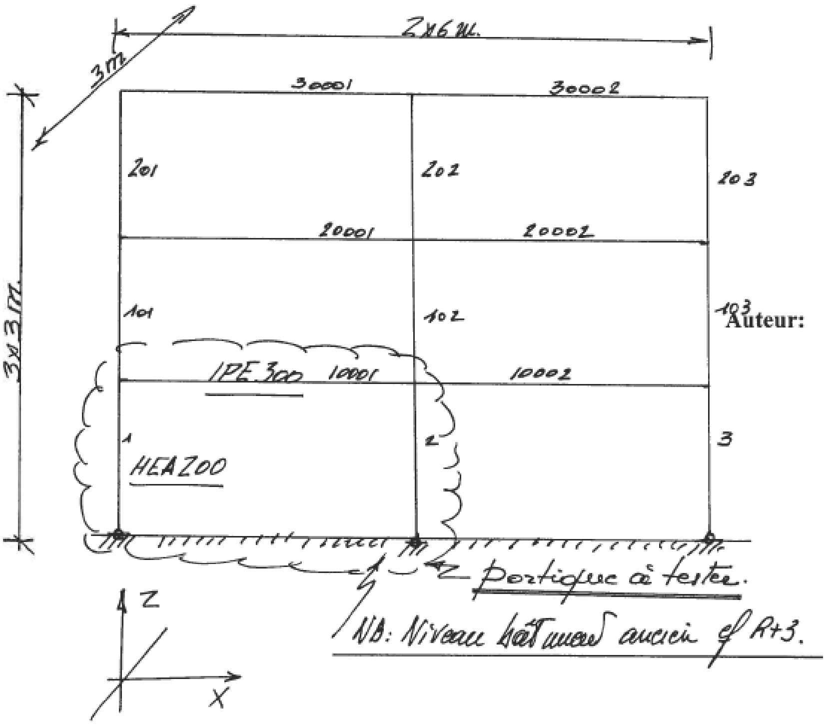


Figure 04: Frame sketch of the structure to be designed and local frame to be tested in laboratory.

For the laboratory test we have isolated one part of the structure "Showed in the cloudy zone of the figure 04".

This part composed of two columns and one beam will be tested in laboratory. This will be the sample for testing.

The main characteristic to be tested is the pinned connection, including:

- Resistance of the concrete wall panel,
    - The concrete surrounding the connection,
    - The connection rods,
    - The steel joint.

Other characteristics to be measured are:

- the rigidity of the connection "pinned",
- the rigidity of the frame, lateral displacement at top of the column,
- vertical displacement at mid span,
- rotation angle at the joint base.

All loadings are the same for each case, dead weight, live loads, slabs, wall, etc except wind and snow than can differ from case to case depending of the geometry of the building.

Wind and snow loads are automatically generated by the software we use for this calculation: ROBOT v21.0.1:

2.1.3. Loading

All loading cases consider for a transverse width (span) of 3 meters. The portal frame is loaded with the following loads. All load combinations are automatically generated by the software.

Loads cases

Self weight

- 1: Frame: automatically included by the software
- 1a: Steel sheeting: 35 daN/m² * 3.0 = 1.05 kN/m of frame.
- 1b: 0.0 “Reserved”.
- 1c: 0.0 “Reserved”
- 2: Composite slab: 15 cm tick weight of concrete: 275 daN/m² * 3.0 = 11.25 kN/m
- 3: Floor and Partitioning: 150 daN/m² * 3.0 = 4.50 kN/m²
- 4: External walls: 50 daN/m² * 3.0 = 1.50 kN/m (note: loaded on columns).
- 5: 0.0 “Reserved”

Live loads

- 6: Live load: 150 daN/m² * 3.0 = 4.50 kN/m (Housing).

Wind and snow

- 13 to 19: Wind and snow automatically generated by the software as explained above.

This example is for loading for the building as in figure 01.

2.1.4. Loads (French text)

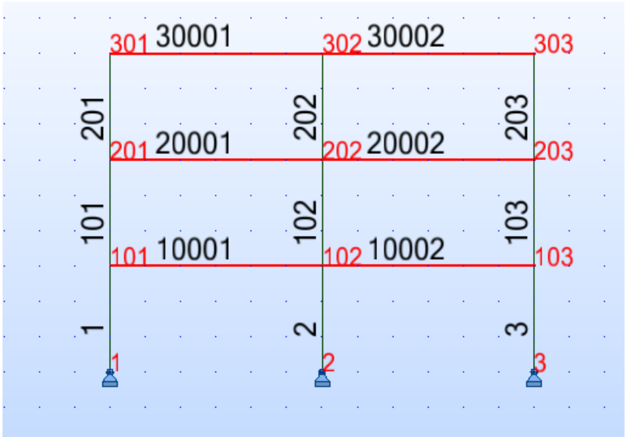


Figure 05: Model sketch

- Cas: 1A19

	Cas	Type de charge	Liste	Valeurs de la charge
	1	poids propre	1A3 101A103 201A203 10001 10002 20001 20002 30001 30002	PZ Moins Coef=1.00
	1	charge uniforme	10001 10002 20001 20002 30001 30002	PZ=-1.05[kN/m]
	1	charge uniforme	30001 30002	
	1	charge uniforme	10001 10002 20001 20002 30001 30002	
	2	charge uniforme	10001 10002 20001 20002 30001 30002	PZ=-11.25[kN/m]
	3	charge uniforme	10001 10002 20001 20002 30001 30002	PZ=-4.50[kN/m]
	4	charge uniforme	1A3 101A103 201A203	PZ=-1.50[kN/m]
	6	charge uniforme	10001 10002 20001 20002 30001 30002	PZ=-4.50[kN/m]
	13	charge trapézoïdale (2p)	203	PZ2=-1.73[kN/m] PZ1=-1.67[kN/m] X2=1.00 X1=0.0 local non projetés relatives
	13	charge uniforme	30002	PZ=1.73[kN/m] local relatives
	13	charge uniforme	30001	PZ=1.73[kN/m] local relatives
	13	charge trapézoïdale (2p)	201	PZ2=-1.08[kN/m] PZ1=-1.05[kN/m] X2=1.00 X1=0.0 local non projetés relatives
	14	charge trapézoïdale (2p)	201	PZ2=-2.37[kN/m] PZ1=-2.30[kN/m] X2=1.00 X1=0.0 local non projetés relatives
	14	charge uniforme	30001	PZ=0.43[kN/m] local relatives
	14	charge uniforme	30002	PZ=0.43[kN/m] local relatives
	14	charge trapézoïdale (2p)	203	PZ2=-0.43[kN/m] PZ1=-0.42[kN/m] X2=1.00 X1=0.0 local non projetés relatives
	15	charge trapézoïdale (2p)	203	PZ2=1.08[kN/m] PZ1=1.05[kN/m] X2=1.00 X1=0.0 local non projetés relatives
	15	charge uniforme	30002	PZ=1.73[kN/m] local relatives
	15	charge uniforme	30001	PZ=1.73[kN/m] local relatives
	15	charge trapézoïdale (2p)	201	PZ2=1.73[kN/m] PZ1=1.67[kN/m] X2=1.00 X1=0.0 local non projetés relatives
	16	charge trapézoïdale (2p)	201	PZ2=0.43[kN/m] PZ1=0.42[kN/m] X2=1.00 X1=0.0 local non projetés relatives
	16	charge uniforme	30001	PZ=0.43[kN/m] local relatives
	16	charge uniforme	30002	PZ=0.43[kN/m] local relatives

	Cas	Type de charge	Liste	Valeurs de la charge
	16	charge trapézoïdale (2p)	203	PZ2=2.37[kN/m] PZ1=2.30[kN/m] X2=1.00 X1=0.0 local non projetés relatives
	17	charge trapézoïdale (2p)	201	PZ2=1.51[kN/m] PZ1=1.47[kN/m] X2=1.00 X1=0.0 local non projetés relatives
	17	charge uniforme	30001	PZ=1.41[kN/m] local relatives
	17	charge uniforme	30002	PZ=1.41[kN/m] local relatives
	17	charge trapézoïdale (2p)	203	PZ2=-1.51[kN/m] PZ1=-1.47[kN/m] X2=1.00 X1=0.0 local non projetés relatives
	18	charge trapézoïdale (2p)	201	PZ2=0.33[kN/m] PZ1=0.32[kN/m] X2=1.00 X1=0.0 local non projetés relatives
	18	charge uniforme	30001	PZ=0.23[kN/m] local relatives
	18	charge uniforme	30002	PZ=0.23[kN/m] local relatives
	18	charge trapézoïdale (2p)	203	PZ2=-0.33[kN/m] PZ1=-0.32[kN/m] X2=1.00 X1=0.0 local non projetés relatives
	19	charge uniforme	30001	PZ=-1.05[kN/m] projetés relatives
	19	charge uniforme	30002	PZ=-1.05[kN/m] projetés relatives

Table 01: Load case: 3 levels building, 2 x 6 m portal frame span, 3 meter transverse span.

Load combinations:

All combinations tested depends of the element to be designed and limit state to be controlled: ULS and SLS.

2.1.5. Combinaisons

- Cas: 7 10 [CM66]

Combinaison/Comp.	Définition
EFF/ 1	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 6*1.50
EFF/ 2	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33
EFF/ 3	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.50
EFF/ 4	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00
EFF/ 5	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 13*1.50
EFF/ 6	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 14*1.50
EFF/ 7	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 15*1.50
EFF/ 8	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 16*1.50
EFF/ 9	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 17*1.50
EFF/ 10	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 18*1.50
EFF/ 11	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 13*1.50
EFF/ 12	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 14*1.50
EFF/ 13	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 15*1.50
EFF/ 14	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 16*1.50
EFF/ 15	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 17*1.50
EFF/ 16	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 18*1.50

Combinaison/Comp.	Définition
EFF/ 17	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 19*1.50
EFF/ 18	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 19*1.50
EFF/ 19	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 6*1.42 + 13*1.42
EFF/ 20	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 6*1.42 + 14*1.42
EFF/ 21	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 6*1.42 + 15*1.42
EFF/ 22	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 6*1.42 + 16*1.42
EFF/ 23	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 6*1.42 + 17*1.42
EFF/ 24	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 6*1.42 + 18*1.42
EFF/ 25	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.42 + 13*1.42
EFF/ 26	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.42 + 14*1.42
EFF/ 27	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.42 + 15*1.42
EFF/ 28	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.42 + 16*1.42
EFF/ 29	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.42 + 17*1.42
EFF/ 30	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.42 + 18*1.42
EFF/ 31	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 6*1.42 + 19*1.42
EFF/ 32	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.42 + 19*1.42
EFF/ 33	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 13*1.42 + 19*0.71
EFF/ 34	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 14*1.42 + 19*0.71
EFF/ 35	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 15*1.42 + 19*0.71
EFF/ 36	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 16*1.42 + 19*0.71
EFF/ 37	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 17*1.42 + 19*0.71
EFF/ 38	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 18*1.42 + 19*0.71
EFF/ 39	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 13*1.42 + 19*0.71
EFF/ 40	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 14*1.42 + 19*0.71
EFF/ 41	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 15*1.42 + 19*0.71
EFF/ 42	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 16*1.42 + 19*0.71
EFF/ 43	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 17*1.42 + 19*0.71
EFF/ 44	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 18*1.42 + 19*0.71
EFF/ 45	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 6*1.33 + 13*1.33 + 19*0.67
EFF/ 46	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 6*1.33 + 14*1.33 + 19*0.67
EFF/ 47	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 6*1.33 + 15*1.33 + 19*0.67
EFF/ 48	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 6*1.33 + 16*1.33 + 19*0.67
EFF/ 49	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 6*1.33 + 17*1.33 + 19*0.67
EFF/ 50	1*1.33 + 2*1.33 + 3*1.33 + 4*1.33 + 5*1.33 + 6*1.33 + 18*1.33 + 19*0.67
EFF/ 51	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.33 + 13*1.33 + 19*0.67
EFF/ 52	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.33 + 14*1.33 + 19*0.67
EFF/ 53	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.33 + 15*1.33 + 19*0.67
EFF/ 54	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.33 + 16*1.33 + 19*0.67
EFF/ 55	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.33 + 17*1.33 + 19*0.67
EFF/ 56	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.33 + 18*1.33 + 19*0.67
EFF/ 57	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 13*1.75
EFF/ 58	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 14*1.75
EFF/ 59	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 15*1.75
EFF/ 60	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 16*1.75
EFF/ 61	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 17*1.75
EFF/ 62	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 18*1.75
EFF/ 63	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 13*1.75
EFF/ 64	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 14*1.75
EFF/ 65	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 15*1.75
EFF/ 66	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 16*1.75
EFF/ 67	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 17*1.75
EFF/ 68	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 18*1.75
EFF/ 69	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 19*1.71
EFF/ 70	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 19*1.71
EFF/ 71	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 13*1.75 + 19*0.86
EFF/ 72	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 14*1.75 + 19*0.86
EFF/ 73	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 15*1.75 + 19*0.86
EFF/ 74	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 16*1.75 + 19*0.86
EFF/ 75	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 17*1.75 + 19*0.86
EFF/ 76	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 18*1.75 + 19*0.86

Combinaison/Comp.	Définition
EFF/ 77	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 13*1.75 + 19*0.86
EFF/ 78	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 14*1.75 + 19*0.86
EFF/ 79	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 15*1.75 + 19*0.86
EFF/ 80	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 16*1.75 + 19*0.86
EFF/ 81	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 17*1.75 + 19*0.86
EFF/ 82	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 18*1.75 + 19*0.86
DEP/ 1	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00
DEP/ 2	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00
DEP/ 3	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 13*1.00
DEP/ 4	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 14*1.00
DEP/ 5	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 15*1.00
DEP/ 6	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 16*1.00
DEP/ 7	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 17*1.00
DEP/ 8	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 18*1.00
DEP/ 9	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 19*1.00
DEP/ 10	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 13*1.00
DEP/ 11	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 14*1.00
DEP/ 12	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 15*1.00
DEP/ 13	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 16*1.00
DEP/ 14	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 17*1.00
DEP/ 15	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 18*1.00
DEP/ 16	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 19*1.00
DEP/ 17	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 13*1.00 + 19*0.50
DEP/ 18	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 14*1.00 + 19*0.50
DEP/ 19	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 15*1.00 + 19*0.50
DEP/ 20	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 16*1.00 + 19*0.50
DEP/ 21	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 17*1.00 + 19*0.50
DEP/ 22	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 18*1.00 + 19*0.50
DEP/ 23	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 13*1.00 + 19*0.50
DEP/ 24	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 14*1.00 + 19*0.50
DEP/ 25	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 15*1.00 + 19*0.50
DEP/ 26	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 16*1.00 + 19*0.50
DEP/ 27	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 17*1.00 + 19*0.50
DEP/ 28	1*1.00 + 2*1.00 + 3*1.00 + 4*1.00 + 5*1.00 + 6*1.00 + 18*1.00 + 19*0.50

Table 04: Load case combination (CM66 Code)

These case figures are extended on every building consideration for one up to three extra levels, for span 12 m and 2 x 6 meter, for transverse spans of 3 and 6+ meter, for fixed or pinned connection on the existing building.

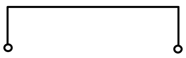
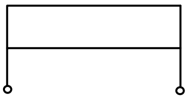
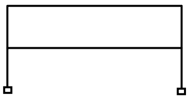
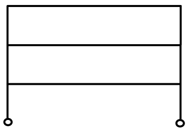
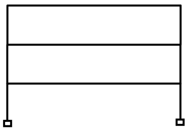
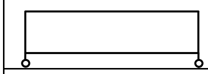
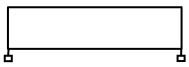
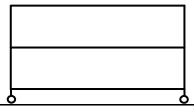
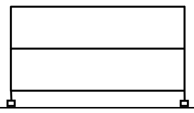
2.1.6. Summary of results for all structural cases and loading cases.

For all the cases the following design characteristics have been summarized in the following table with Mmax on the beam, Nmax in the column. Note that Nmax refers usually for central column for 2x6 meter portal frame cases.

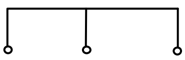
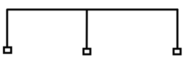
- Type of frame: simple pinned or fixed,
- Single span of 12 meters or 2 x 6 meter span,
- One, two or three levels,
- 3meter or 6 meters transversal span.

Sections for columns are from HEA series, sections for beams are from IPE series.

One single span portal frame:

Type of Frame	Mmax (N*m/m)	Section Beam 3m/6m width	Nmax (N/m)	Section Column 3m/6m width
	61368	IPE360/IPE500:	38714	HEA280/HEA360
	61229	IPE360/IPE500	38350	HEA280/HEA360
	117521	IPE450/IPE600	125752	HEA360/HEA450
	113638	IPE450/IPE600	124679	HEA360/HEA450
	122215	IPE450/IPE600	165290	HEA340/HEA500
	112225	IPE450/IPE600	165474	HEA340/HEA500
	114018	IPE400/IPE600	????	HEA280/HEA360
	114236	IPE550/IPE600	99234	HEA280/HEA360
	117236	IPE450/IPE600	161424	HEA360/HEA450
	113330	IPE450/IPE600	158033	HEA360/HEA450
	121836	IPE500/IPE600	223614	HEA360/HEA500
	117817	IPE500/IPE600	219390	HEA360/HEA500

Two continuous portal frames

Type of Frame	Mmax (N*m/m)	Section Beam 3m/6m	Nmax (N/m)	Section Column 3m/6m
	21621	IPE220/IPE360	41624	HEA200/HEA260
	20277	IPE270/IPE360	41082	HEA200/HEA260

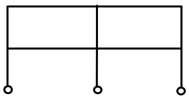
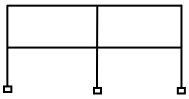
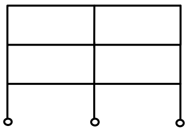
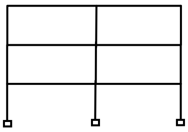
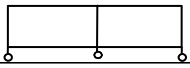
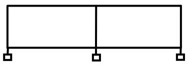
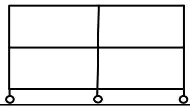
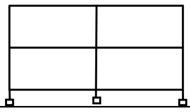
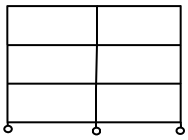
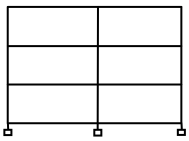
	41068	IPE300/IPE400	149327	HEA240/HEA300
	41138	IPE300/IPE400	149155	HEA240/HEA300
	44454	IPE300/IPE400	210241	HEA240/HEA300
	43562	IPE300/IPE400	210003	HEA240/HEA300
	32552	IPE270/IPE360	119866	HEA200/HEA260
	31095	IPE270/IPE360	123227	HEA200/HEA260
	34983	IPE300/IPE360	190262	HEA240/HEA300
	33340	IPE270/IPE360	189000	HEA240/HEA300
	40261	IPE300/IPE400	274312	HEA240/HEA300
	43621	IPE300/IPE400	273132	HEA240/HEA300

Table 05: Results summary, maximum effort in beams and columns – sections choice.

Assuming portal frame: pinned or fixed at the base, we can use lighter section but still heavy. The differences are not very significant between pinned or rigid bases because that the beam are the governing element for the design:

For beams

3x12m span pinned frame: will use up to IPE500 section
6x12m span pinned frame: will use up to IPE 600 section

3x2x6m span pinned frame: will use up to IPE300 section
6x2x6m span pinned frame: will use up to IPE400 section

For columns

3x12m span pinned frame: will use up to HEA360 section
6x12m span pinned frame: will use up to HEA500 section

3x2x6m span pinned frame: will use up to HEA240 section
6x2x6m span pinned frame: will use up to IPE 300 section

These sections are quite heavy for vertical extensions!!

As you can see this design is not relevant with the sizing of continuous supporting walls in concrete: width = 20 cm.

3. Proposed investigation on connection

This approach has been discussed during the group meeting in July 2009. Orientations are to be given for testing on a proposed connection type. The discussion has run around **two types of connections + one continuous wall connection**:

Remembering meeting in Cracow

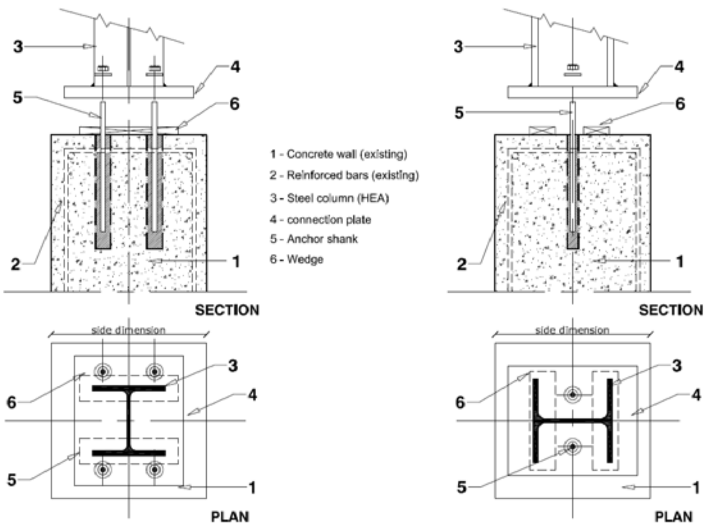


Figure 06: Point connection: Connection every 3 m laterally, 6 m span, rolled sections, considered as pinned connections.

3.1. Case One: Pinned connection

The end plate of the column will be fixed by two lateral anchors (or 2 x 2) into the concrete of the longitudinal concrete panel wall creating a pinned connection. This is not possible to create fixed connection on the limited size of 20 cm.

Thus a pinned connection shall be proposed as in figure 08.

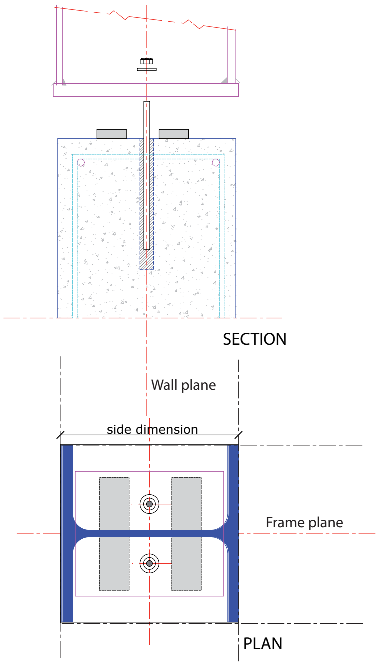


Figure 08: Pinned configuration on longitudinal wall (20 cm thick)

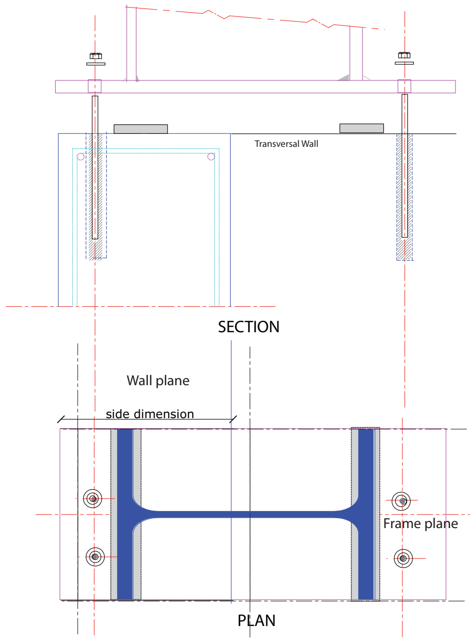


Figure 09: Semi-rigid? configuration on transverse wall (Thickness can be extended up to for IPE360)

3.2. Case two: Fixed (Semi-Rigid) connection

We can fix up to IPE 360 section on transverse wall (running through the inner space of the building from external wall to external wall, partionning) as the base plate and flange width can be sized up to 200 mm. This plate can be fixed by two lateral anchors into the concrete creating a pinned connection as in case 1. This is also possible to create a fixed connection, bending along the strong axis of the section, on this limited size, by extending the base plate at the front and back of the section flange (Figure 09).

3.3. Case three: Continuous pinned connection

To be used with light gauge elements and works. Special attention on these elements was asked by two partners (Figure 10). Unfortunately, light gauge prefabricated wall elements testing has been cancelled late 2009 due to limited availability material disposal.

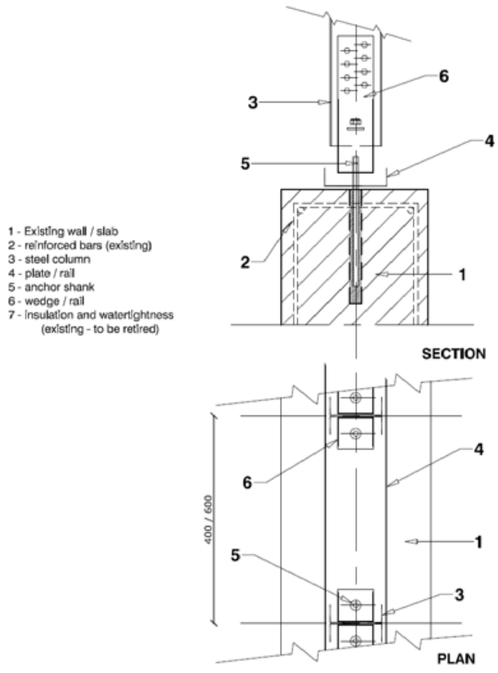


Figure 10: Continuous connection: one connection every 60 cm, U section bed, light gauge sections.

4. Laboratory tests

4.1. Test rig

The portal frame to be tested rest on the wall elements especially build for this test,

- External wall element is used for the pinned connected frame,
- Transversal wall element is used for the fixed connected frame,
- Transversal wall element is used for the continuous light gauge elements (PRZ and Arcelor demand). Forgotten in October!

The base of the test rig in constructed in concrete with the following form, 3 m x 6 m floor dimension as on figure 11.

The above three configurations correspond to a frame: 2 x 6 m span portal frame at 3 m transverse span inter distance, and could even designed for 1 or 2 levels, and be extended to 3 levels with specific bracing cross in place of the portal frame.

The test sample will be a portal steel frame: 3m high, 6 m span, fixed on two concrete wall panels: 3 meter long, 0.8 meter high, 20 cm thick.

The connection to be tested will be point concrete/steel: need to anchor the steel frame into the existing concrete panel.

Sample of the concrete panels shall be fixed on a concrete base to fit the laboratory ground anchors network. The steel frame shall be maintained laterally to avoid any buckling.

The drawing shows a plan view of the concrete wall to be tested test. The 6 m length element can be reduced to 2 x 1 meter length separated elements.

The concrete panel wall (20 cm thick) is on the upper part of the concrete base. The walls show a H form, 6 meter web concrete panel wall and 2 x 3 m meter flanges concrete panel walls.

Note: Changed in October! Limited to 2.4 x 4.8 m.
Note: We have to reduce this size from 3 m to less than 2.4 m. See proposal below figure17.

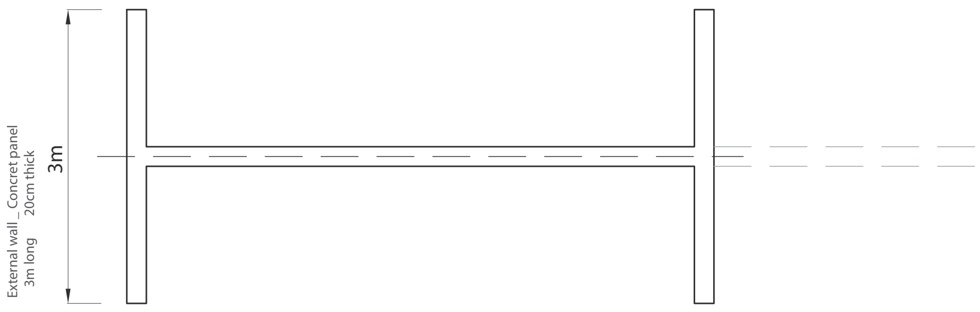


Figure 11: Base of the test rig

This arrangement can perform 3 different types of tests:

- One test on a pinned connection of portal frame on the external concrete panel wall of the building, in this case on the flange of the H, using a HEA 200 section to be connected to the wall,
- One test on a "semi-rigid" fixed connection of portal frame on the internal partitioning concrete panel wall of the building, in this case on the web of the H, using a IPE 270 section to be connected to the wall,
    - Can be in the pinned or semi-rigid form to be decided,
- One test on a continuous connection of a light gauge wall element on the internal concrete panel wall of the building, in this case on the flange of the H, using a fabricated steel wall to be furnished by ArcelorMittal or PRZ. Forgotten in October.

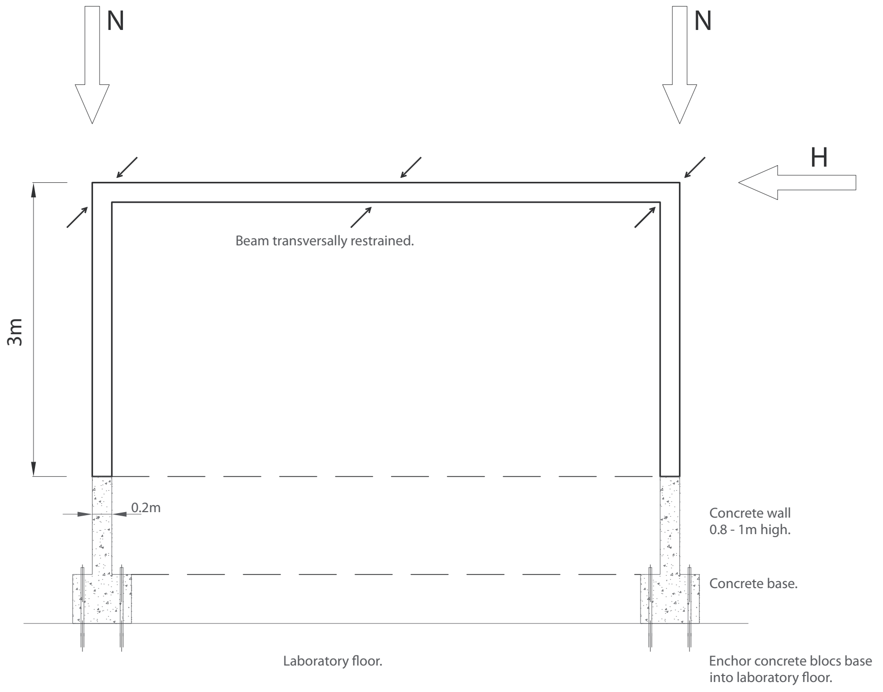


Figure 12: Portal frame to be tested in laboratory part of the complete structure

The figure shows the portal frame resting on the concrete panel wall, and the concrete panel wall resting on the concrete base.

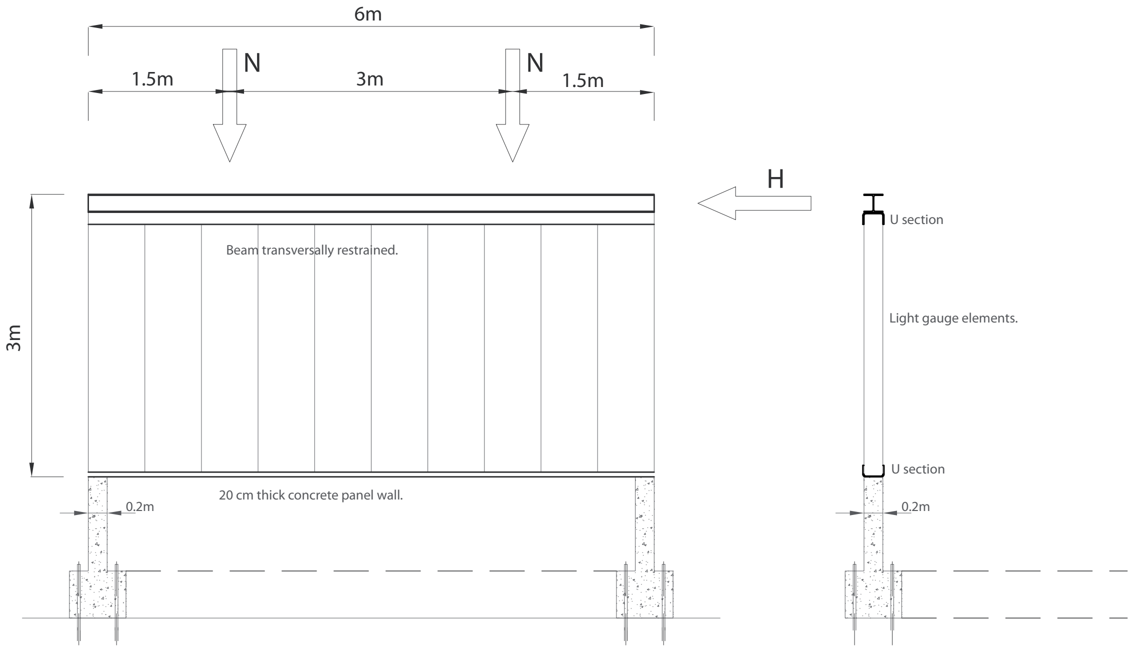


Figure 13: Possible arrangement for testing longitudinal fabricated wall (ArcelorMittal or PRZ) Forgotten in October

1. **If we consider the point connection** on continuous concrete panel wall of 20 cm thickness the problem will be to fix steel rods into the RC Rbars cage of the existing frame using: Frictional anchors, Treaded rods, chemical or expansion connection.

Our investigation shows that if we want to use laminated sections (columns and beams) and point connections (end plate) for extension, the sizing is very restrictive with:

- Only laminated section in the range of HEA200 pinned in the xx' direction (free rotation along the yy' direction) "to fit in the 20 cm width" and reach RC Rbars cage.
- Or stronger sections (IPE Range) but fixed at the liaison with a transverse wall. They can then be fixed joint.
- In both case the lever arm for moment to be transmitted is very low (if fixed joint).
- So the joint has a limited transfer capacity, limited only to vertical loading and shear. We consider that there is no moment capacity.

The following figure shows how two tests can be carried on the same base: One minimum size (HEA200 section) fixed on the concrete external panel wall and one stronger section fixed on transverse panel wall. Concrete panel wall are simulated on the test rig, by the 1.0 m x 0.2 m concrete elements.

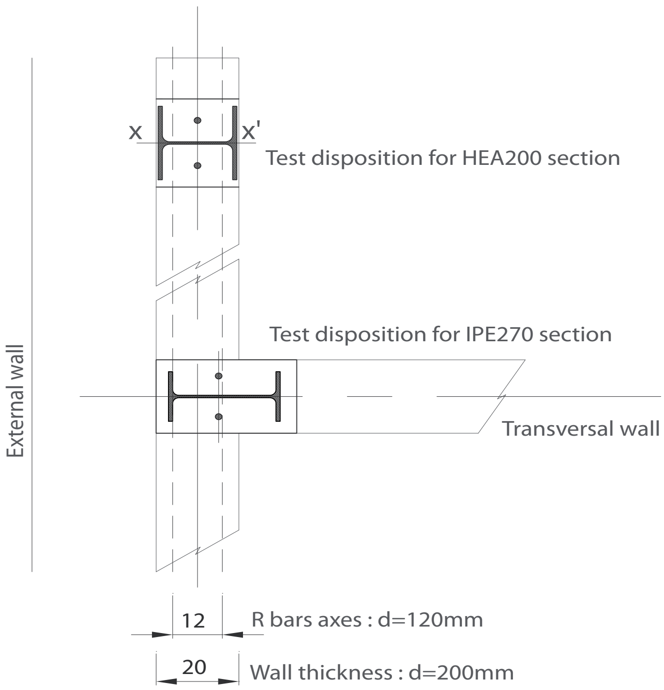


Figure 14: Two possible arrangements for testing pinned laminated section frames joints

For this arrangement anchors shall be used to form a pinned connection, there is no opportunity in the sizing to use fixed connections.

2. **If we consider fixed connection (in fact semi-rigid),** one of the tests can be made in this aspect **on the transverse wall.** The 20 cm thickness of concrete wall cannot be used for HEA sections (above HAE200) but this is OK for IPE section up to IPE 500. The width of an IPE 500 is 200 mm. Compared to a HEA 200 (Iyy = 3500 cm4), the equivalent IPE section range at IPE 240 (Iyy = 2892 cm4) or IPE 270 (Iyy = 5790 cm4). We propose to test an IPE 270 fixed at the root of the transverse wall.

Figure 15 shows this opportunity. One test with an HEA section, one test with IPE section.

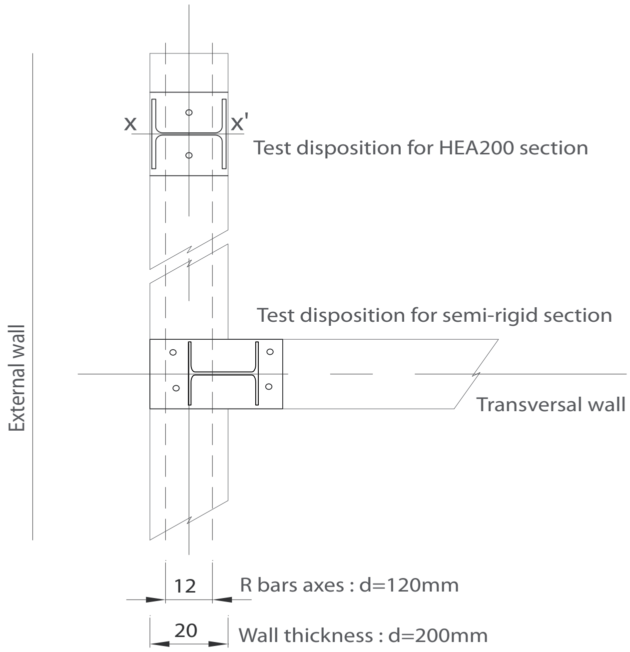


Figure 15: Two possible arrangements for testing pinned and semi rigid laminated section frames – nearly the same as in figure 14

Continuous wall arrangement forgotten in October!

4.2. Concrete wall panel

Note: This arrangement does not fit the present fixing system on ground floor of the laboratory. Arrangement has been made to fit laboratory floor and a size factor will be included in the analysis of the results.

The concrete wall panel will have a thickness of 200 mm (as in real buildings). It shall be fixed on the laboratory floor and we propose the following arrangement:

- The longitudinal wall itself simulated by a 3 meter long specimen combined with a transversal wall specimen with length to be defined: 800 mm high, 200 mm thick concrete panel, fixed on a concrete base wall (block) to fit the laboratory ground on the fixing lines.
- The base wall is provided to give a strong rigidity to the element to be tested and to avoid any rotation of the base during the test.
- The base wall width to be defined following the laboratory arrangement.
- The transverse wall is constructed on the same way. Its length can be reduced from 6 meter to less, provided its rigidity is sufficient. We think that a section of wall of 1 meter long can provide this rigidity.
- Moreover, in way to rigidify the ends of the longitudinal wall we propose one “return element” as showed on figure 17.

The following picture gives the schematic elevation cut into the wall and the base wall, longitudinal and transversal one.

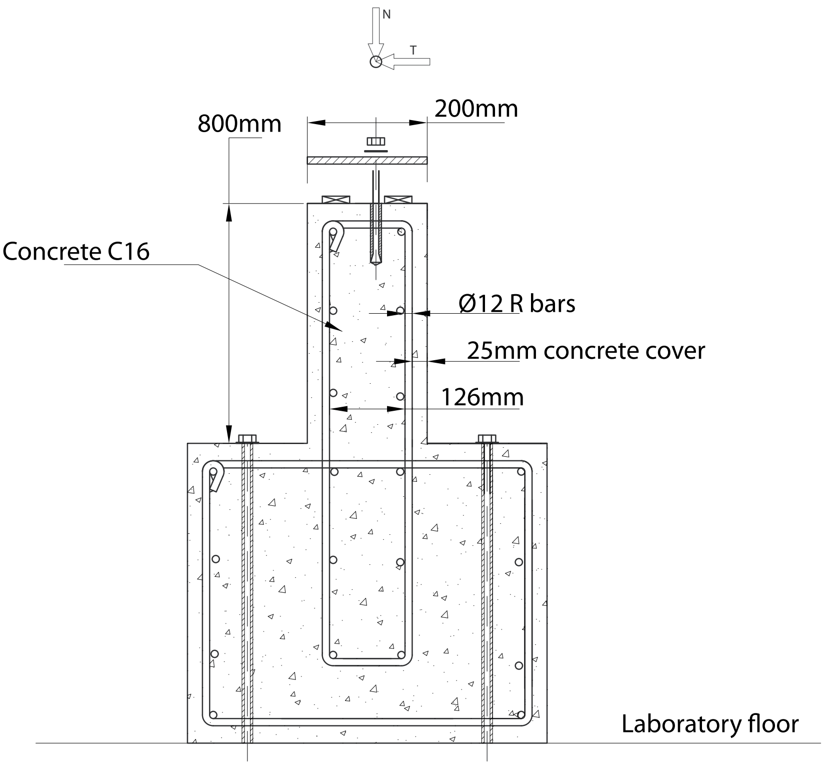


Figure 16: Local fixing of the steel column on the concrete panel wall,

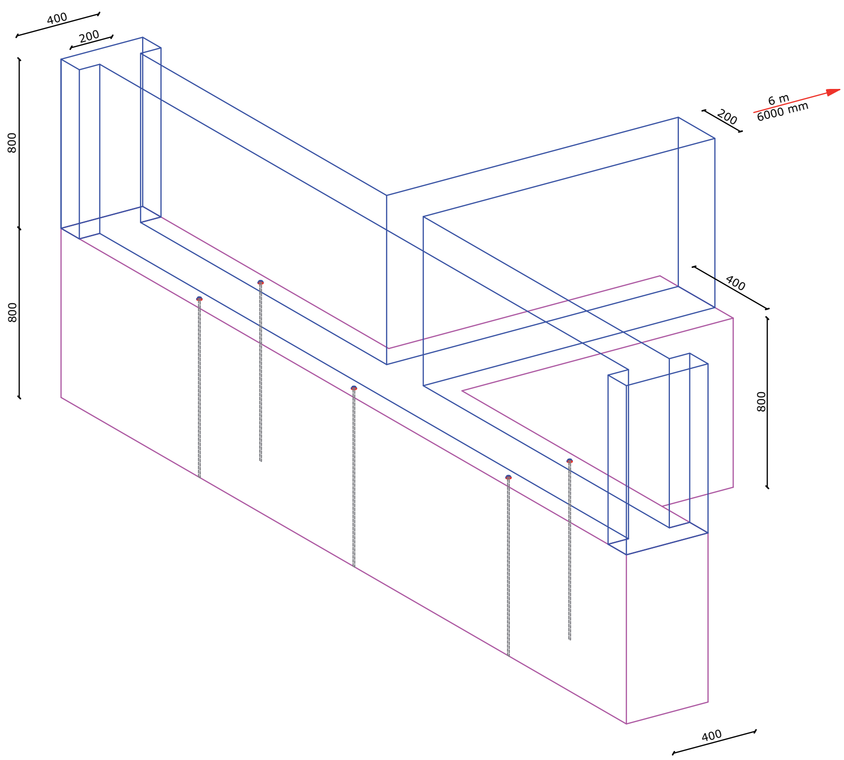


Figure 17: The upper part is the concrete panel wall, the lower part is the concrete base.
Note: the steel column is not showed.

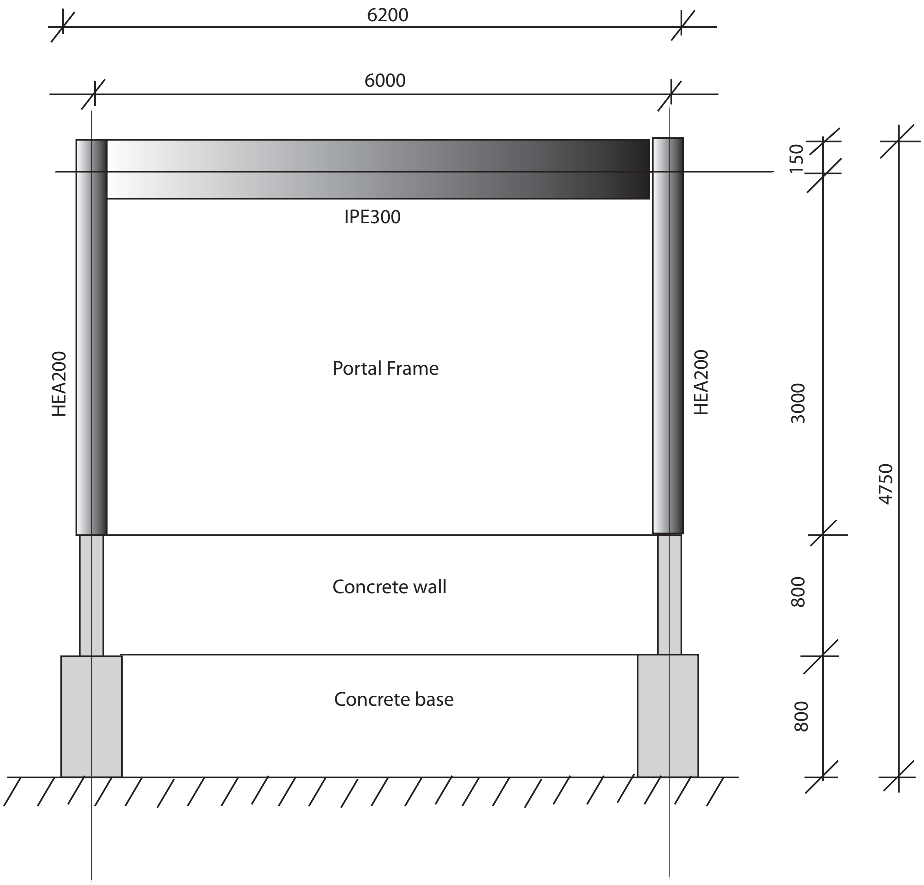
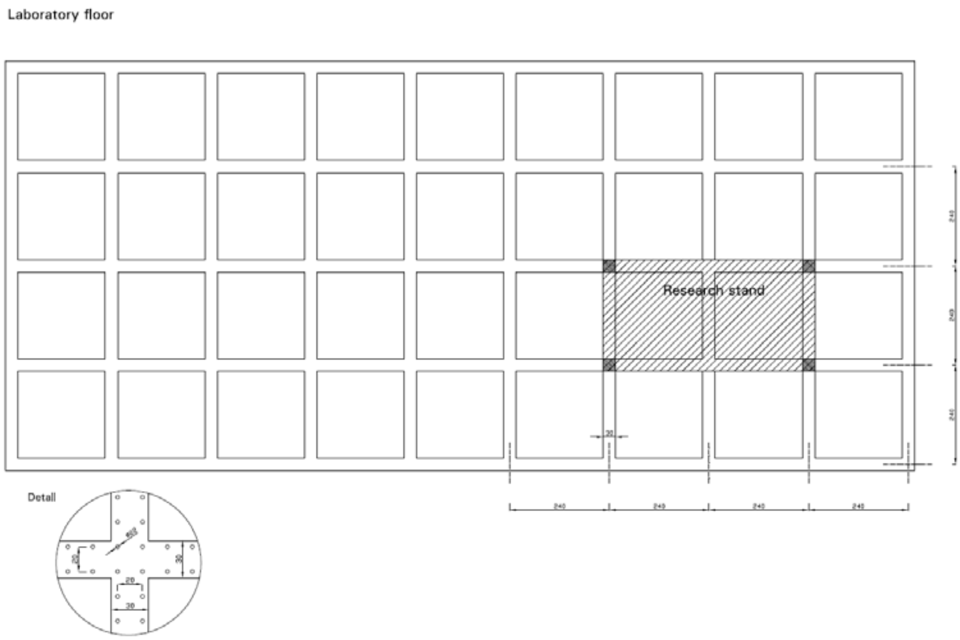


Figure 18: Portal frame arrangement on the rig

Note: Below, floor arrangement received from Alexander! in November.



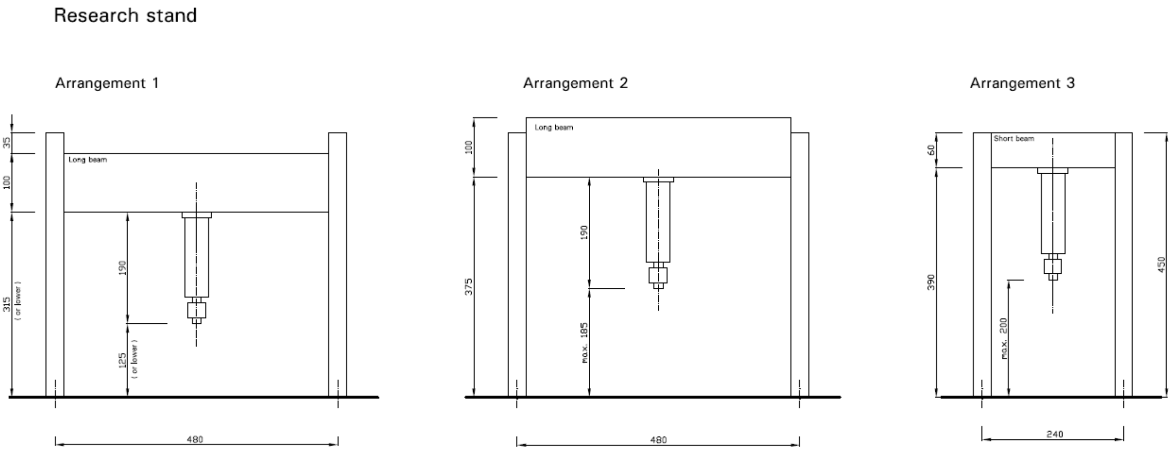


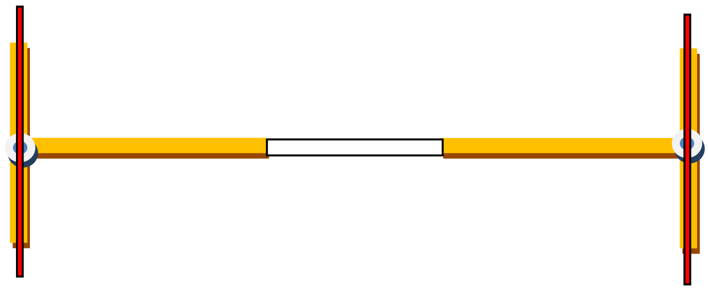
Figure 19: Laboratory floor arrangement and rig disposition opportunities

Observing these figures we can arrange the tested frame as on the figure 20 below:

- Arrangement 1: on the middle of the research stand (right),
- or arrangement 2: along one fixing path (left),

One of these arrangements shall be chosen.

Orange forms are the walls, red forms are the loading frames, circular forms are the jacks.



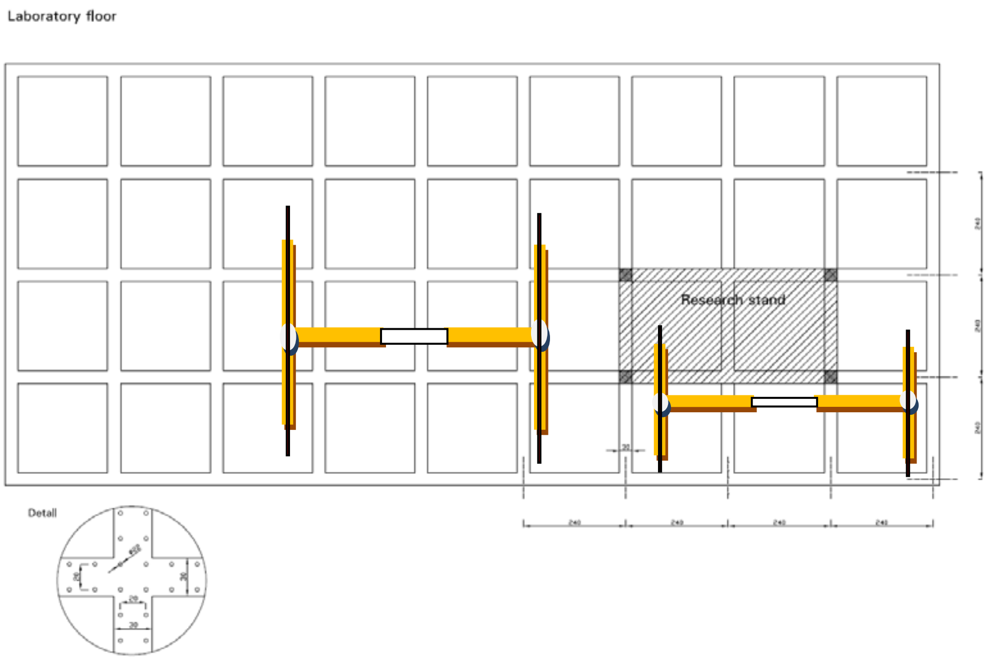


Figure 20: Proposed positioning of the test rig on the laboratory floor

Note: This arrangement does not fit the laboratory floor on three points.

- To fix the wall body on the ground we need a concrete block with width greater than 200 mm, the width of the supporting base wall (see figure 16) shall be greater than 200 mm. On the laboratory floor the maximum distance between fixing points is 200 mm. This does not fit together. !!!
- Normally from our point of you the base wall shall have a width of no less than 600 mm, largely above the 200 mm available. We can discuss on a width of 400 mm if the resistance of the fixing can be managed within this dimension.

See proposal 1 from CTICM.

- The maximum vertical position from the laboratory floor of the loading jack is 200 cm as showed for arrangement 3. In our proposal the high of the tested arrangement is:

Concrete base: proposed:	400 mm high,
Panel wall sample: to allows for flexural behaviour,	proposed 800 mm,
Steel portal frame (fixed on the wall height):	3 m = 3000 mm,
Total:	4200 mm.

This is quite above the available height at the loading point in the laboratory, which is limited to 2000 mm (arrangement 3).

So, if we keep the laboratory arrangement as it is presented we have to design a portal frame not higher than 2000 – 1200 mm = 800 mm?

Alexander: has proposed an new arrangement : See proposal 2!

Proposals 1

The figure 21 is an example of proposed arrangement to fix the concrete body onto the laboratory floor: In the three directions, a small extension of the concrete base is required to fix it on the laboratory floor. If we consider a width of the concrete base of 400 mm, (to be designed), we suggest to extend the base by 400 x 400 mm and fix it by rods on the square mesh 200 x 200 mm, as it appears to be done on the laboratory floor fixing mesh.

- For a 2400 mm portal frame rig as in arrangement 3 from Alexander! (Figure 19).
  This is the right arrangement of figure 20. To be compared to a 3 m span concrete wall as expected in real situation!

  The maximum total longitudinal length of the concrete base is:

Distance between rig frame (as proposal 3):	2400 mm
Size of the rig columns (HEA 200?)	-200 mm
Two fixing plots (200 x 200 mm)	-400 mm
Small return wall for rigidity (2 x 200 mm)	-400 mm
Maximum concrete wall length than can be tested	**1400 mm**

- For a 4800 mm portal frame rig as in arrangement 1 or 2 from Alexander ! (figure 19)

  The maximum total longitudinal length of the concrete base is:

Distance between rig frame (as proposal 3):	4800 mm
Size of the rig columns (HEA 200?)	-200 mm
Two fixing plots (200 x 200 mm)	-400 mm
Small return wall for rigidity (2 x 200 mm)	-400 mm
Maximum concrete wall length than can be tested	**3800 mm**

  The 3 meter span fit within this distance! This is the left arrangement of figure 20.

For the transverse wall, normally the distance is 6 m, but we don’t need such distance and we can reduce to 1 meter! if needed. This arrangement is showed in figure 21.

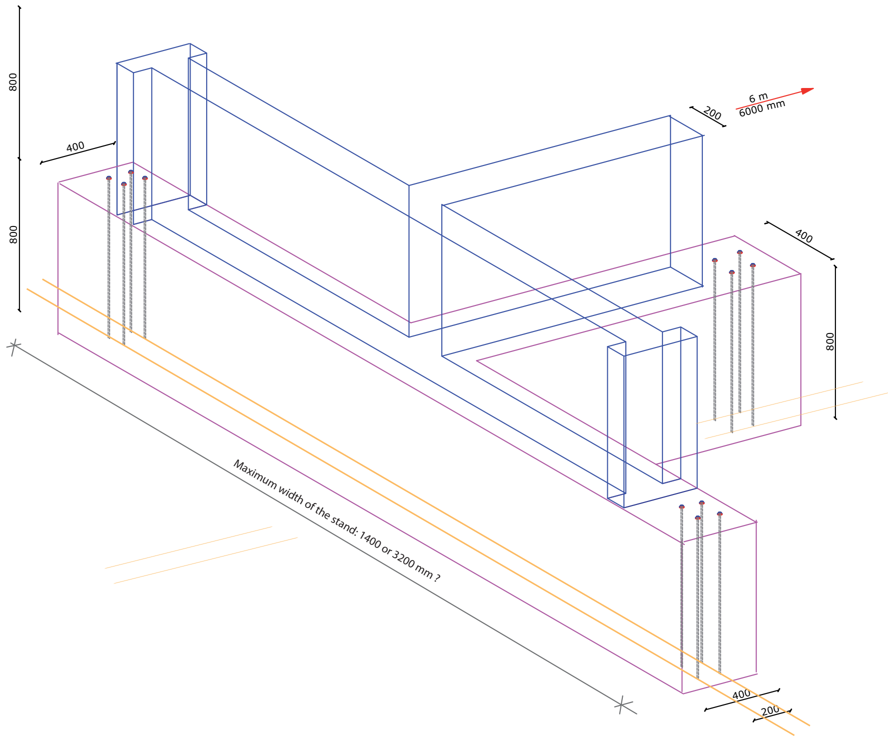
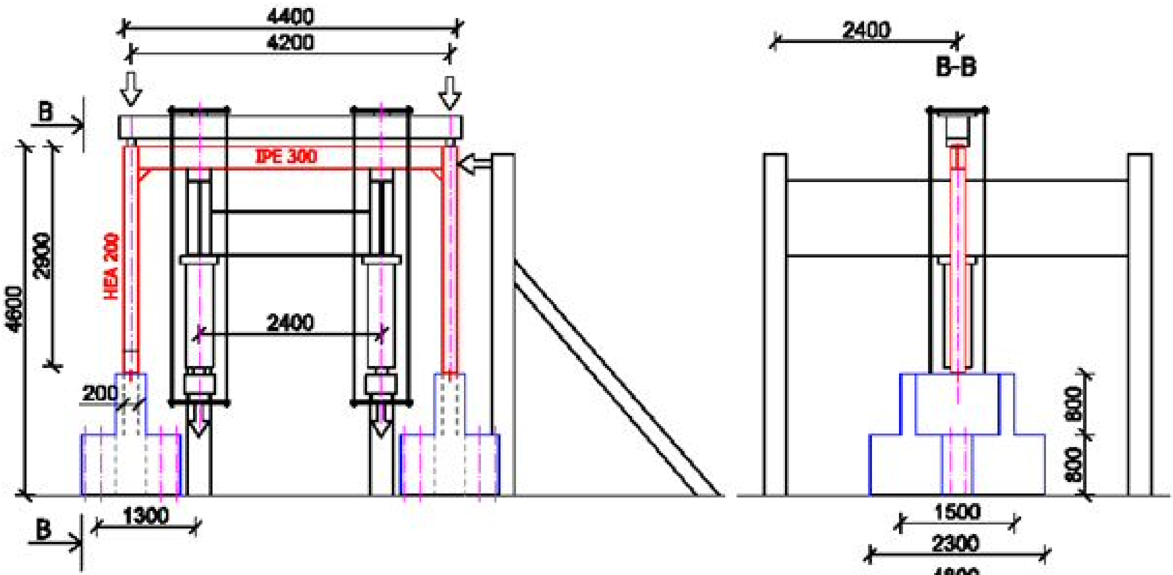


Figure 21: Example of proposed arrangement for the testing rig concrete base

Proposal 2 from PRZ



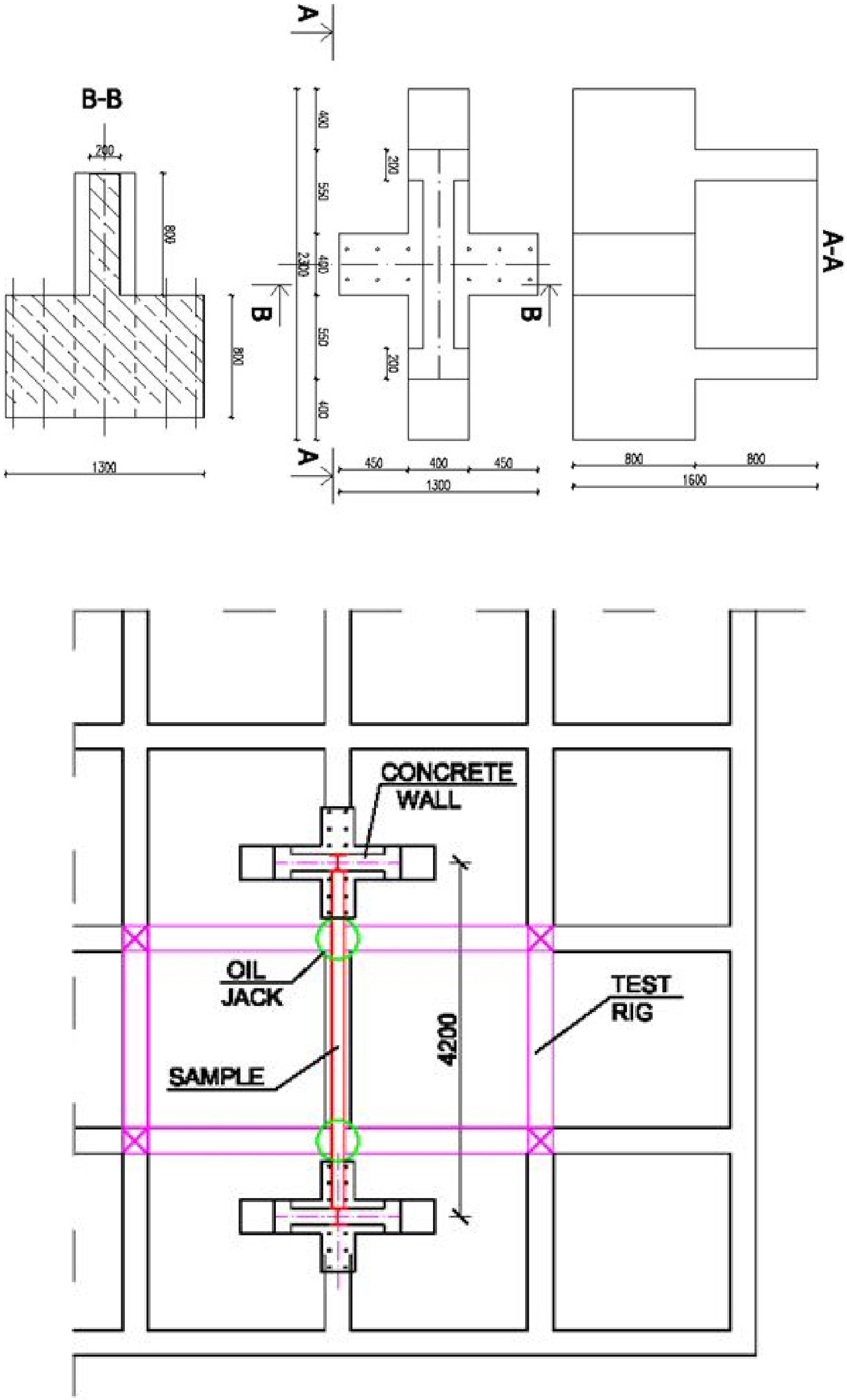


Figure 22: Example of proposed arrangement for the testing rig frame, increase high of the rig – PRZ Proposal

With this arrangement, the jack is operated from the bottom of the rig and there is no more restriction in the sample height. More over the sample concrete base has been modified in dimensions to fit the laboratory ground.

Expecting some small changes in results we can have a comprehensive results interpretation from testing from the second proposal for basic arrangement of the first proposal. So this arrangement has been accepted for testing.

Results to come from PRZ University after testing.

At the end of February the concrete base were flowed and the steel frame constructed. The concrete base should cure during March and montage was expected to begin in mid March.

4.3. Fastening systems

Post-installed anchors can be of several types such as expansion anchors, undercut anchors, concrete screws, bonded anchors, bonded expansion anchors and bonded undercut anchors. The following figure gives examples of such fasteners. Design considerations are regarded used producers specifications (Hilty, Koko, Etanco, etc). This shall fit the sizing oft the existing wall support.

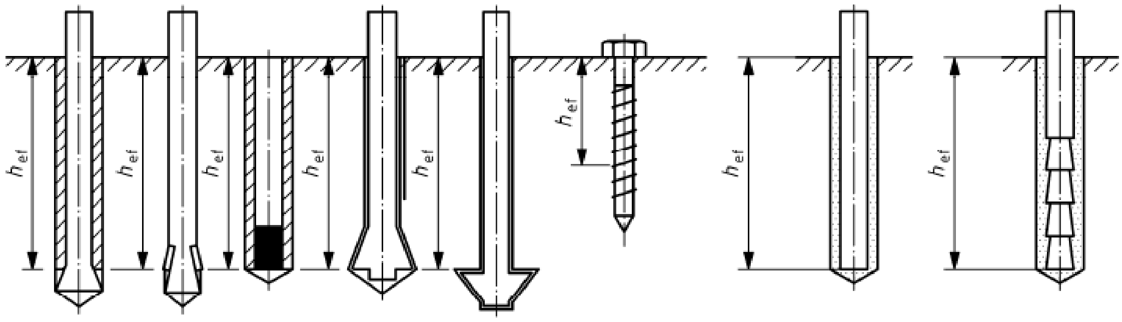


Figure 23: Post-installed fasteners types

- Torque controlled fastener, sleeve type,
- Torque controlled fastener, wedge type,
- Deformation controlled fastener,
- Undercut fastener type1,
- Undercut fastener, type 2,
- Concrete screw,
- Bonded fastener,
- Bonded expansion anchor.

Design consideration, group discussion, industrial opportunities have been discussed during the meeting group in July and shoud rize to specification for testing of connection device. Tests should be made at the Rezszow University of Technology during the second semester 2009 and first semester 2010 .

4.5. Connection devic

We propose to use HVA/HVU anchors from HILTI but this choice should be done in agreement with Alexander.

- Maximum transverse distance between two anchors at point connection (see drawing point connection): 160 mm for HEA200 sample, 100 mm for IPE270 sample.
- Anchor type to be chosen in regular production range, (Hilti, Koko, Etanco, or others).

A separate design approach has been made on the connecting devise. The goal was to choose the best connecting devise that can fit the concrete wall and its dimensional characteristics.

The design follows the French approach for design of connection into concrete (same as ETAG Annex C or ACI 318 chapter 22). We have calculated the ultimate strength of the connection taking count of a safety factor Gamma s = 1.4.

Another approach was to use the design tables of HILTI for the related product : as choosen HVA = HVU + HAS. These tables are annexed to the present document.

Others HILTI systems of connections have been regarded (Mechanical expension connectors, Chimical expension connectors) but do not look efficient for one unique reason : The edge distance, too short for a 200mm thick concrete wall. Edge distance is 100 mm at a maximum and drastically limit the performance of the connector. HVA is the simples and most efficient system in our case.

4.5.1. Design approach summary

The goal is to approach the best fitting connecting devace for the anchorage of the steel base on the concrete wall

Design for tensile resistance – One single connector in a set of several connectors

Data	M8	M16	M20	M33
Concrete Tensile resistance (kN)	10.3	28.9	52.4	142.7
Steel tensile resistance (kN)	17.5	78.9		345.2
Tensile resistance (kN)	10.3	28.9		142.7
Depth influence factor	1.0	1.0	1.0	1.0
Concrete stenght factor	0.95	0.95	0.95	0.95
Anchor spacing	0.81	0.70	0.65	0.63

factor				
Edge distance factor	1.0	0.80	0.70	0.66
Final resistance (Ultimate including safety factor) - kN	7.92	15.37	22.65	59.94
Final resistance (Ultimate excluding safety factor) - kN	11.09	21.51	31.64	83.92

Note: If we want a better resistance we can increase the length of the rod and change depth influence factor. In that case the new resistance shall be safe and compared with steel rod resistance and not only concrete resistance.

Design for shear resistance and 100 mm edge distance, One single connector in a set of several connectors

Data	M8	M16	M20	M33
Shear failure (kN)	2.2	5.6	10.3	30.7
Concrete stenght factor	0.95	0.95	0.95	0.95
Anchor spacing factor	5.27	2.44	1.18	1.88
Edge distance factor	1.0	0.80	0.85	0.66
Load Direction factor	1.0	1.0	1.0	1.0
VRd,c - Final resistance (Ultimate including safety factor) - kN	11.41	12.98	16.15	24.20
VRd,s – Shear resistance – steel (Ultimate, including safety factor)	7.90	34.6	75.1	155.3
Shear resistance – steel (Ultimate, including safety factor)	7.9	12.98	16.15	24.20
Shear resistance – steel	11.06	18.17	22.61	33.88

(Ultimate, excluding safety factor)				

As in most case the concrete will collapse before the steel rod, we propose to use steel grade 5.8 only.

The design resistance are given in plain concrete without reinforcement. In any case, the reinforcement will have large influence on the resistance, but cannot at the present time be estimated. We will observe during the test., this is an important part of the test results.

4.5.2. First test

Ultimate strength – HEA 200 – 2 anchors x 2 joints (laboratory test) x 3 joints (real building).

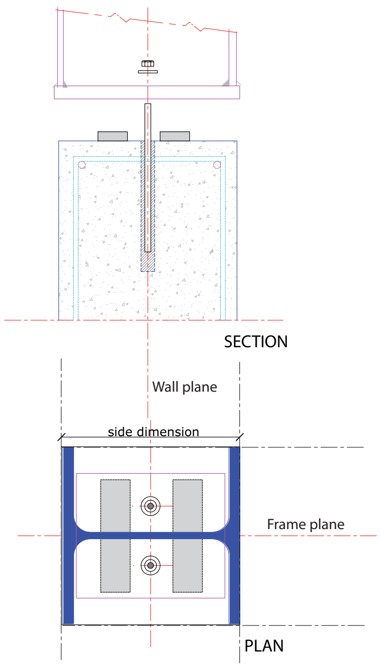


Figure 24: Joint to be tested

kN	Tensile x1	Tensile x 2 1 joint	Tensile 2 joints	Tensile 3 joints
M8	11.09	22.18	44.36	66.54
M16	21.51	43.02	86.04	129.06
M20	31.64	63.28	126.56	189.84
M33 (* note)	83.92	167.84	335.68	503.52
	Shear x 1	Shear x 2 1 joint	Shear 2 joints	Shear 3 joints

M8	11.06	22.12	44.24	66.36
M16	18.17	36.34	72.68	109.02
M20	16.15	32.30	64.60	96.90
M33 (* note)	33.18	67.76	135.52	203.28

4.5.3. Second test

Ultimate strength – IPE 270 – 2 anchors x 2 joints (laboratory test) x 3 joints (real building).

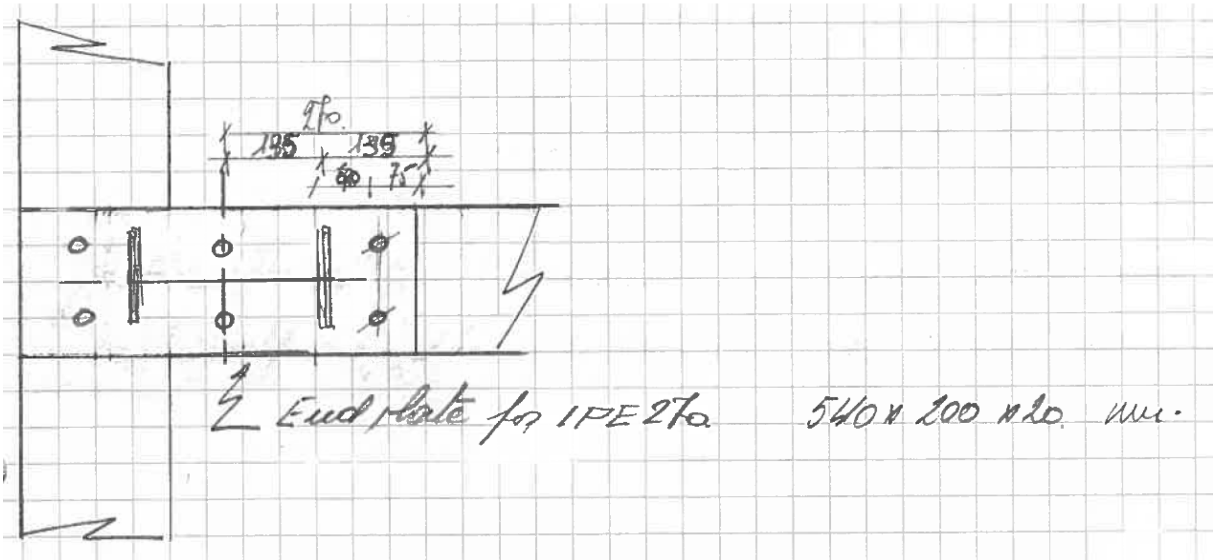


Figure 25: joint to be tested

kN	Tensile x1	Tensile x 6 1 joint	Tensile 2 joints	Tensile 3 joints
M8	11.09	66.36	132.72	199.08
M16	25.51	153.06	306.12	451.18
M20	31.64	189.84	379.68	569.52
M33 (* note)	83.92			
	Shear x 1	Shear x 6 1 joint	Shear 2 joints	Shear 3 joints
M8	11.06	66.36	132.72	199.08
M16	18.17	109.02	218.04	327.06
M20	16.15	96.90	193.80	290.70
M33 (* note)	33.18	203.28	406.56	609.54

4.5.4. NOTES

- Note:* The values for M33 anchors cannot be used because the criterium on minimum edge distance is not met.

Cracked concrete

- The fact that the concrete is cracked has not been considered in this design! This is normal because the laboratory concrete will not be cracked! we hope so!. Nevertheless HILTI indicate to apply a cracked concrete factor of 0.65 if any! This is not taken into consideration at this stage but shall be considered in design!

- The positive effect of the vertical loading is not taken into account.
- The positive effect of the reinforcement cage is not taken into account.

4.5.5. I have chosen

HILTI adhesive anchors: Product HVA = HVU capsule with HAS and HAS-rods

We propose M20x170/48 product

These are adhesive anchors (chemical). HILTI does not recommend this type of anchors for heavy loads “the reason, I don’t know!”

These anchors are correct suited for concrete, pre-setting systems, low inter-distance of anchors, low edge distance, good for corrosion, water tight and fire resistant.

We do not choose expansion anchors “as recommended by HILTI for one unique reason:

As the anchor works with concrete expansion “it is designed for”, and our support wall is rather thin “200 mm”, the edge factor is dramatically small, sometime 0 and these anchors are not suited. This is due to lateral splitting of the wall concrete of the thin wall. Expansion anchor are best suited for massive concrete, this is not our case.

4.6. Comparison with design loads

4.6.1. Vertical loads

A vertical load on the central column of the real building has been estimated **at 270 kN** (see design of extension document) for a 3 levels extension. This is the greatest result we can expect for the load in columns.

To simulate the frame behaviour of the extension, we consider this vertical load of 270kN at each column of the frame sample for laboratory test.

Is this load too high for the concrete wall ?

If we consider a steel base of 200 mm x 200 mm this will produce a compression stress of 6.75 N/mm^2.

This is quite the half of the design resistance of the concrete in compression!

4.6.2. Shear loads

The expected maximum shear force per column (central column) is about **150 kN** (3 levels, wind, 6 m span, 6 m width).

Pinned connection: Two rods

If we check the shear resistance of the joint: one column, two rods, the connection can shear resist:

kN	M8	M16	M20	M33
Shear Resistance	25	50	88	191

Fixed connection: Six rods

If we check the shear resistance of the joint: one column, six rods, the connection can shear resist:

kN	M8	M16	M20	M33
Shear Resistance	75	150	264	573

Without positive influence of the vertical load and the presence of the reinforcement into the wall.

4.7. Test loading

The medium vertical loading to be applied on the test sample (2 levels without roof slab, or 1 level with a roof slab) is: N=150 kN to 270 kN, fixed value during the test.

We propose to load with a vertical load: N = 270 kN.

The transverse horizontal loading to be applied from 0 tons up to failure (150 kN ??). Expected shear design shear force on the central column is 90 kN (factorized).

The horizontal loading shall be controlled Load control at the beginning of the loading, and displacement control near the failure load.

5. Specifications for the testing rig

Note that this chapter has been discussed in October and altered to reduce the size of the rig. The first value gives the expected dimension to fit the real construction elements, the second value gives the experimental sample to fit the laboratory groud.

NOTE: The following red text to be limited to the two tests on laminated sections. After some discussion with Alexander and Giorgia in October the test on continuous light steel panel wall have been forgotten, limiting the test to pinned laminated section connections.

Note: In the same situation, the laboratory floor arrangement does not permit to perform test of the size 3 x 3 x 6 meters and Alexander has made a demand that shall be limited to the following sizes: 4.8 meters by 2.4 meters, height 3.45 to 3.9 meters.

The size of the test rig shall be at maximum as:

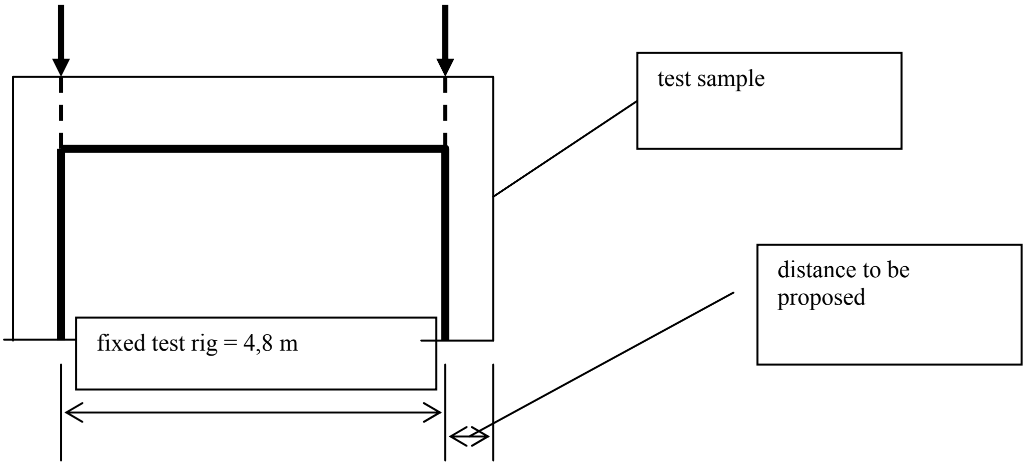


Figure 26: Alternative and final accepted proposal from PRZ

Real element sizing	Sample for laboratory testing
• 6.0 m span, • 3 m transverse dimension, • 3 meter height of the portal frame, • 0.8 m height of the concrete wall, • 0.4 m height of the concrete base.	• 4.8 m span, • 2.4 or 4.8 m transverse dimension, • 3.15, 3.75 or 3.9 m height of the portal frame, • 0.8 m height of the concrete wall, • 0.4 m height of the concrete base (changed from 0.8 to 0.4).
	Note that the rig dimension shall be coherent with the arrangement of the laboratory floor, especially for the anchors of the concrete base onto the floor and the positioning of the loading jacks.

5.1. Test rig description

The test base will be composed of the concrete panel bases, fixed on the laboratory floor. The concrete panel wall is simulated by a concrete wall, 0.8 m high, 0.2 m thick, with an form of an double cros (3.0 x 4.8 m) resting on the floor. In way to fix the panel wall on the ground, and to reach the anchors in the laboratory floor, an intermediate concrete base should be constructed depending of the arrangement of the floor.

We propose the following arrangement for the concrete panel (as on figure 22):

- A concrete base made of a reinforced concrete simulating the continuity of the concrete, fixed on the laboratory slab in coherence with the anchors arrangement of the laboratory. High of the concrete block between 40 to 100 cm, base (fitted to the laboratory rig size),
- Rbars in the concrete block to fix the concrete wall panel, shall be able to transfer, N,M, T loads,
- One concrete panel 20 cm thick in continuity of the concrete block, length (fitted to the laboratory rig size: 2 x 3 m + 1 x 6 m), high: 0.8 meter,
- The steel section pinned connection on the concrete panel, two possible arrangements.

Concrete base proposal from PRZ as follow:

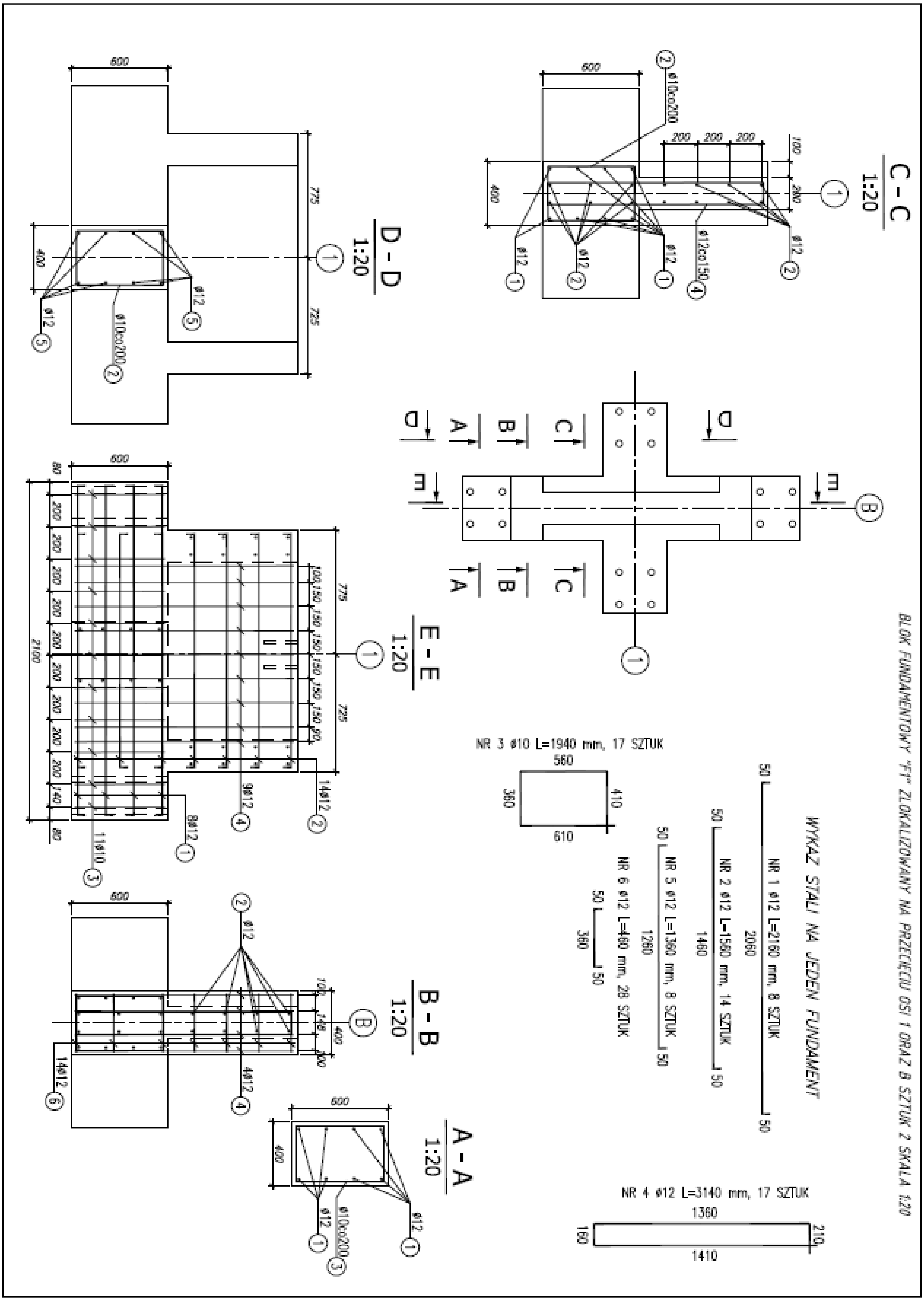


Figure 28: Concrete base proposal - PRZ

5.2. *Specifications for concrete base*

Specifications for the testing should be as follow (to be confirmed and designed):

Concrete walls: Longitudinal and transverse

- Concrete type: mid 60's concrete, C20, expected exposed to weather condition, testing should be made with a **concrete type not exceeding C16** (as discussed!!).
- Concrete wall panel sample for external wall simulation (Flange part and web part of the X form):
-
    - Width: 200 mm,
    - High: 800 mm,
    - Length: 1500 (1400) mm for flange part,
    - Vertical Rbars in the concrete panel wall: 2 layers 4 RB Φ12/m of wall,
    - Horizontal Rbars in the concrete panel wall: 2 layers 4 RB Φ12/m of wall,
    - Concrete cover on Rbars: 25 mm?? (better 40 mm ??),
    - One anti cracking meshes, to be discussed !!!

The concrete base: to be arranged for the laboratory floor. We propose to use same concrete and same arrangement for Rbars, thus:

- Width: 600 mm, (400 mm: see Alexander),
- High: 800 mm, as a proposal but can be less above 400 mm, 600 mm final,
- Length: As above for transverse flange part, 2100 (1400) mm, and web part (6000 mm),
- Rbars as above: this is a proposal as nothing can be calculated.
- Vertical Rbars in the concrete panel wall: 2 layers 4 RB Φ12/m of wall,
- Horizontal Rbars in the concrete panel wall: 2 layers 4 RB Φ12/m of wall,
- Concrete cover on Rbars: 25 mm?? (better 40 mm ??),
- One anti cracking meshes, to be discussed !!!

5.3. *Specification on steel*

Steel column

- Steel grade: S235 or above
- Steel column: HEA200

Steel column base

- Steel base to fit the HEA 200:
    - Steel base plate 210 x 200 x 20 mm (Note: 210 mm to allow welding along the external face of the flange.
    - Welding dimension: Throat: 10 mm inner site, external site as possible 10 mm too!

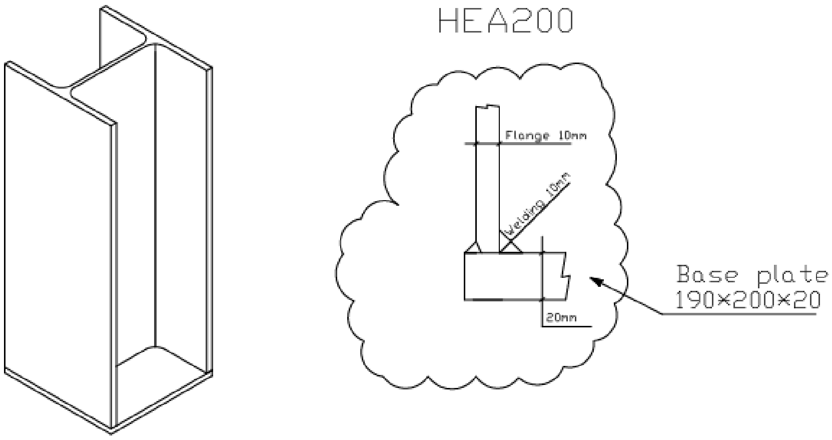


Figure 29: Column base plate

5.4. Specifications for the portal frame joint

- Column HAE 200
- Beam IPE 300
- Joint between HEA 200 Column and IPE 300 Beam: This material fit together ideally:
- End plate welded on the IPE 300

Sizing

See annexed document!

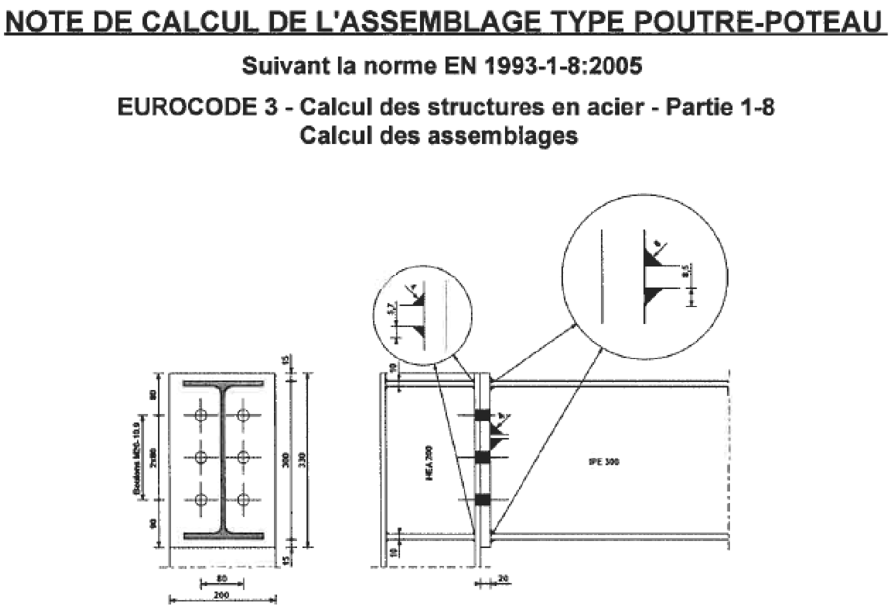


Figure 30: Joint between beam and column

5.5. Specification for connection device

I have chosen

HILTI adhesive anchors: Product HVA = HVU capsule with HAS and HAS-rods

We propose M20x170/48 product

These are adhesive anchors (chemical). HILTI does not recommend this type of anchors for heavy loads “the reason, I don’t know!”

These anchors are correct suited for concrete, pre-setting systems, low inter-distance of anchors, low edge distance, good for corrosion, water tight and fire resistant.

We do not choose expansion anchors “as recommended by HILTI for one unique reason:

As the anchor works with concrete expansion “it is designed for”, and our support wall is rather thin “200 mm”, the edge factor is dramatically small, sometime 0 and these anchors are not suited. This is due to lateral splitting of the wall concrete of the thin wall. Expansion anchor are best suited for massive concrete, this is not our case.

So this is what I propose!

6. Specification on measurements

What to measure?

Figure 31 gives a schematic drawing showing the expected minimum measurements to be made and recorded at least.

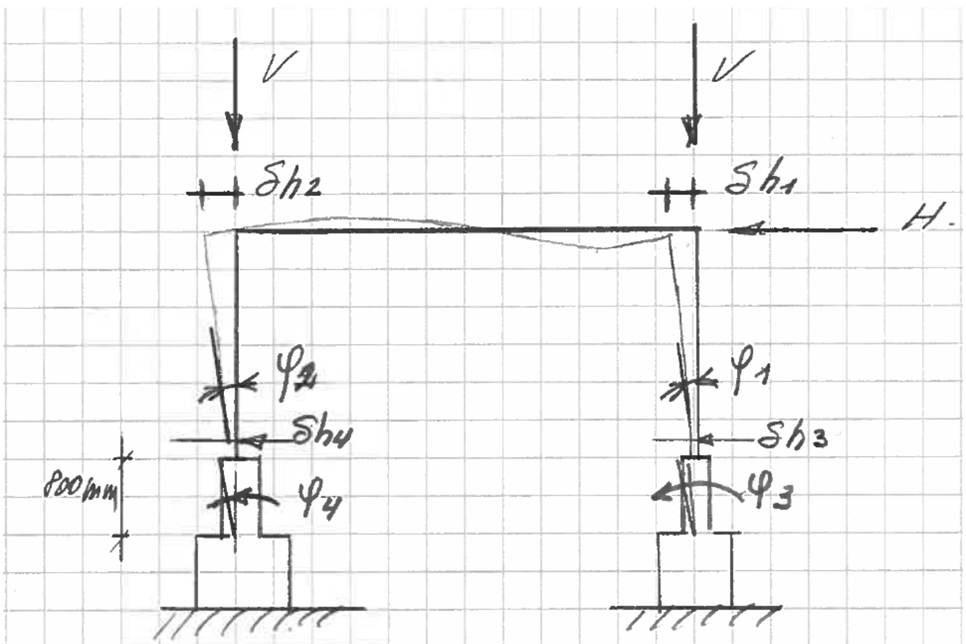


Figure 31: Measurements to be made

- Horizontal displacement at top of the columns: δh1 and δh2
- Rotation at bottom of columns: Φ_1 and $\Phi_{2,}$

- Horizontal displacement at bottom of columns: δh, and δh,,
- Rotation at bottom of the concrete sample Φ, and Φ, (the sample is the 200 mm thick wall).

All these measurements to be discussed with Alexander! Need more measurements?

Need strain gauge measurements? Need measurements in the portal frame? What I have proposed is related to the connection itself and not the steel frame

Need measurements into rods ?? Strain gauge and how to fix those gauges??

Note: For the second test with IPE270 section and connection build on the transversal wall, with the horizontal loading assumed from right to left: the behavior of the connection will differ between the right and the left joint due to the following situations:

Left: Compression on the concrete at the external edge of the wall, tension on the transverse wall

Right: Tension at the external edgeof the wall, compression on the transverse wall.

So need measurements on each site, left and right.