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DOCUMENT CHECKED BY:	Ing. Roberto Firpo		
DOCUMENT APPROVED BY:			

To the care of:	**FLR Engineering S.A.R.L.**
Address	Route de l'Aeroport
ZIP CODE	BP900
Town	Pointe Noire Rep. du Congo
SUBJECT:	Analysis of a metallic framework inside of an Hangar, aimed to contain offices and warehouses
LOCATION	
ENDUSER COMMITTANT	
BUILDER	INAER Aviation SpA
FRAMEWORK CODE	FRL_ENG_001

The following documents regards our best offering for:

CAE Analysis	☑	CAD Support	☒	Mech Design	☒

Of the furniture asked by you accordingly to the described specification.

REV.	DATE	DESCRIPTION	RED.	CHK.
2				
1				
0	25/09/2016	First Release	[signature]	[signature]

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1.1 REPORT OF STRUCTURAL CALCULATION

1.1.1 ANALYSIS AND CHECKS OUT WITH THE AID OF CALCULATION CODES

This report of structural calculation, according to point § 10.1 of DM 14/01/08, includes a description of the general criteria for analysis and verification too. Following addition to the information provided in § 10.2 of DM same regarding analysis and verification conducted with the help of calculation codes.

Location of the structure	
City	
Municipality	
Province	
Region	
Longitude	
Latitude	

Parameters of the structure			
Use class	Life Vn [years]	Use parameter	Vr period [years]
III	50.0	1.5	75.0

Overview of the structure
Structure is a carpentry framework aimed to contain offices and warehouses. It's build out of standard culumnar profiles HEB200 and HEB100 welded and cantileverd to the ground. Eight of these HEB200 are vertically cantilevered to the soil forming a rectangular planform. These are connected at midspan via HEB200 to define first floor framework. Orthogonnaly HEB100 define main framework of the first floor. Perimeter is then closed via CLS Brick sizing 150x200x400 Roof is made out of lighten insulated aluminum profiles.

In the following origin and characteristics of the software codes; title, producer and distributor, version, extremes of licensing agreements:

Origin and Characteristics of the Codes of Calculation	
Title:	PRO_SAP PROfessional Structural Analysis Program
Producer-Distributor	2S.I. Software e Servizi per l'Ingegneria s.r.l., Ferrara
End-user data	NUMITALIA SRL

A careful preliminary examination of documentation accompanying the software made it possible to assess the reliability and fitness for particular case. The documentation provided by the manufacturer and distributor of software, contains a comprehensive description of the theoretical basis and algorithms used, identification of fields of use, and test cases entirely resolved and commented, accompanied by the input file necessary to reproduce the elaboration:

Reliability of codes used
2S.I. has tested the reliability and robustness of the software code through a significant number of cases in which the results of numerical test were compared with theoretical solutions. Documents containing some of the most significant cases handled are at the following address: http://www.2si.it/Software/Affidabilità.htm

In the following is indicated kind of structural analysis (static, dynamic, linear or nonlinear) and the method adopted to solve the structural problem and the methods followed for the design and verification of sections. It reports load combinations and in the case of non-linear calculations, the load paths followed; load configurations used for the design of structure in question were comprehensive for design-verification.

Kind of structural analysis	
Static linear	YES
Static non-linear	NO
Seismic static linear	NO
Seismic dynamic linear	NO
Seismic static nonlinear (prop. masses)	NO
Seismic static nonlinear (prop. mode)	NO
Seismic static nonlinear (triangular)	NO
Project-verifying the data	
Reinforced concrete	D.M. 14-01-2008
Steel	EN 1993-1-1:2005
Wood	D.M. 14-01-2008
Masonry	D.M. 14-01-2008
Seismic action	
Standard applied for seismic action	D.M. 14-01-2008
Combinations of load cases	
Allowable tension	NO
SLU	YES
SLV (SLU with earthquake)	NO
SLC	NO
SLD	YES
SLO	NO
SLU ground A1	NO
SLU ground A2	NO
SLU ground G	NO
Combination caracteristic (rare)	YES
Combination frequent	NO
Combination almost permanently (SLE)	NO
SLA (accidental fire)	NO

The structural elements are controlled for safety according to the construction theory methods.
To estimate the tensile-deformation state induced by the static loads, the structural analysis is carried out according to the displacement method .
To estimate the tensile-deformation state induced by the dynamic loads (among which the seismic load), the structural analysis is carried out according to the method of the modal analysis and response spectra in terms of acceleration.
The structural analysis is carried out according to finite element method. This method schematize the structure by using elements connected in a fixed number of points, i.e. nodes.
The nodes are defined according to three Cartesian coordinates within global reference system.
The unknowns of the problem (within the methods of displacements) are the components of the nodes referred to a global reference system (displacements with respect to X, Y, Z, rotations around X, Y, Z).
The problem is solved by means of a system of linear algebraic equations, whose know terms represent the loads applied to the structure and appropriately concentrated on nodes:

K * u = F where K = stiffness matrix
u = nodal displacement vector
F = nodal force

The element actions and/or tensions, which are generally referred to the local reference system, are deduced from the displacements obtained by means of the problem solution.
The utilized reference system is composed of a clockwise system of Cartesian coordinates XYZ. Axis Z is assumed as vertical and directed upwards.
The elements utilized for the simulation of the structure static scheme are listed below:

TRUSS type element (truss)
BEAM type element (beam)
MEMBRANE type element (membrane)
PLATE type element (plate - shell)
BOUNDARY type element (boundary)
STIFFNESS type element (stiffness matrix)
BRICK type element (solid element)
SOLAIO type element (macro element made up of several membranes)

Structural model achieved with:	
nodes	72
elements D2 (trusses, beams, columns)	108
elements D3 (walls, mats, shells)	0
elements solaio	0
elements brick	0
Model structural size [cm]:	
X min =	-1500.00
X max =	0.00
Y min =	-155.00
Y max =	155.00
Z min =	0.00
Z max =	560.00
Vertical structures:	
Trusses	NO
Pillars	SI
Walls	NO
Shear walls (membrane behavior)	NO
Properties not vertical:	

Trusses	NO
Beams	SI
Shells	NO
Membranes	NO
Orizzontamenti:	
Solaio with rigid floor	NO
Solaio without rigid floor	NO
Type of boundary conditions:	
Nodes bound rigidly	SI
Nodes bound elastically	NO
Nodes with seismic isolators	NO
Foundations point (plinths / plinths on pole)	NO
Foundations type beam	NO
Foundations type mat	NO
Foundations with solid elements	NO

Arrangements for presentation of results.
This report, in addition to explain in detail the input data and results of the analysis in tabular form, contains a series of images; for data input: solid view of the structure nodes and elements numbers static load configurations configurations of seismic loading, centres of gravity with the masses and eccentricity for most significant load combinations (statistically more onerous for the design) deformed shapes diagrams and envelopes of action map of tensions reaction vectors map of pressures on the soil for the project-verifying diagram of reinforcement percentage of material exploitation maps of verifications most significant for the various limit states
General information on the development and reasoned judgement of acceptability of the results.
The program comprises a series of automated controls (check) which allow the identification of modelling errors. At the end of the analysis automatic control identifies the presence of abnormal movements or rotations. It can therefore claim that calculations are correct and complete. The results of calculations have been checked that prove the reliability. This assessment included a comparison with the results of simple calculations, performed with traditional methods and adopted, even during the first proportioning of the structure. In addition, on the basis of considerations relating to the state of tensions, deformation, and strains, has assessed the validity of the choices made in modelling of the structure and actions. Is attached at the end of this report list synthetic carried out (checks balance between reactions and loads applied, comparisons between the results of the analyses and assessments simplified, etc.)..

1.2 REFERENCE BUILDING CODES

1. Internal Affairs and Infrastructure Law and Civil Protection Gennaio 2008 e allegate "Norme tecniche per le costruzioni".
2. DM Infrastructure and Transportation 14 Settembre 2005 e allegate "Norme tecniche per le costruzioni".
3. D.M. LL.PP. 9 Gennaio 1996 "Norme tecniche per il calcolo, l'esecuzione ed il collaudo delle strutture in cemento armato, normale e precompresso e per le strutture metalliche".
4. D.M. LL.PP. 16 Gennaio 1996 "Norme tecniche relative ai <<Criteri generali per la verifica di sicurezza delle costruzioni e dei carichi e sovraccarichi>>".
5. D.M. LL.PP. 16 Gennaio 1996 "Norme tecniche per le costruzioni in zone sismiche".
6. Circolare 4/07/96, n.156AA.GG./STC. istruzioni per l'applicazione delle "Norme tecniche relative ai <<Criteri generali per la verifica di sicurezza delle costruzioni e dei carichi e sovraccarichi>>" di cui al D.M. 16/01/96.
7. Circular Adv. 10/04/97, n.65AA.GG. istruzioni per l'applicazione delle "Norme tecniche per le costruzioni in zone sismiche" di cui al D.M. 16/01/96.
8. D.M. LL.PP. 20 Novembre 1987 "Norme tecniche per la progettazione, esecuzione e collaudo degli edifici in muratura e per il loro consolidamento".
9. Circular Adv. 4 Gennaio 1989 n. 30787 "Istruzioni in merito alle norme tecniche per la progettazione, esecuzione e collaudo degli edifici in muratura e per il loro consolidamento".
10. D.M. LL.PP. 11 Marzo 1988 "Norme tecniche riguardanti le indagini sui terreni e sulle rocce, la stabilità dei pendii naturali e delle scarpate, i criteri generali e le prescrizioni per la progettazione, l'esecuzione e il collaudo delle opere di sostegno delle terre e delle opere di fondazione".
11. D.M. LL.PP. 3 Dicembre 1987 "Norme tecniche per la progettazione, esecuzione e collaudo delle costruzioni prefabbricate".
12. UNI 9502 - Procedimento analitico per valutare la resistenza al fuoco degli elementi costruttivi di conglomerato cementizio armato, normale e precompresso - edizione maggio 2001
13. Ordinance of Prime Minister n. 3274 del 20 marzo 2003 "Primi elementi in materia di criteri generali per la classificazione sismica del territorio nazionale e di normative tecniche per le costruzioni in zona sismica" e successive modificazioni e integrazioni.
14. UNI EN 1990:2006 13/04/2006 Eurocodice 0 – General criteria of design.
15. UNI EN 1991-1-1:2004 01/08/2004 Eurocodice 1 – External forces - Part 1-1: General Forces – Unit of volume weights, weight load and overloads on structures and buildings.
16. UNI EN 1991-2:2005 01/03/2005 Eurocode 1 – Structure forces - Part 2: Loads due to trafic on bridges.
17. UNI EN 1991-1-3:2004 01/10/2004 Eurocode 1 - Structure forces - Part 1-3: General loads – Snow actions
18. UNI EN 1991-1-4:2005 01/07/2005 Eurocodice 1 - Structure forces - Part 1-4: General loads – wind loads
19. UNI EN 1991-1-5:2004 01/10/2004 Eurocodice 1 - Structure forces - Part 1-5: General loads – thermal loads
20. UNI EN 1992-1-1:2005 24/11/2005 Eurocode 2 – Design of concrete structures - Part 1-1: General rules and rules for buildings
21. UNI EN 1992-1-2:2005 01/04/2005 Eurocode 2 - Design of concrete structures - Part 1-2: General Rules – Design against fire
22. UNI EN 1993-1-1:2005 01/08/2005 Eurocode 3 – Design of Steel Structures - Part 1-1 General rules and rules for buildings
23. UNI EN 1993-1-8:2005 01/08/2005 Eurocodice 3 - Design of Steel Structures - Part 1-8: **Design of Links, constraints and joints.**
24. UNI EN 1994-1-1:2005 01/03/2005 Eurocode 4 – Design of concrete reinforced steel structure- Part 1-1: General rules and rules for buildings
25. UNI EN 1994-2:2006 12/01/2006 Eurocodice 4 - Design of concrete reinforced steel structure - Part2: General rules and rules for bridges

26. UNI EN 1995-1-1:2005 01/02/2005 Eurocode 5 – Design of Wooden Structures - Part 1-1: General rules and rules for buildings
27. UNI EN 1995-2:2005 01/01/2005 Eurocode 5 – Design of Wooden Structures - Part 2: Bridges.
28. UNI EN 1996-1-1:2006 26/01/2006 Eurocode 6 – Design of masonry structures - Part 1-1 General rules and rules for buildings
29. UNI EN 1996-3:2006 09/03/2006 Eurocode 6 - Design of masonry structures - Parte 3: Semplified method of computation for unreinforced masonry
30. UNI EN 1997-1:2005 01/02/2005 Eurocode 7 – Geotechnic design - Part 1: General Rules
31. UNI EN 1998-1:2005 01/03/2005 Eurocode 8 – Seismic resisting structures design - Part 1: General rules, sismeic action and rules for buildings.
32. UNI EN 1998-3:2005 01/08/2005 Eurocode 8 Seismic resisting structures design - Part 3: Evaluation and adjustments of buildings

UNI EN 1998-5:2005 01/01/2005 Eurocode 8 - Seismic resisting structures design - Part 5: Foundations, containment structures and geotechnic aspects.

NOTE on the chapter "standard normative": shows the 'list of the regulations implemented in the software. The standards used for the structure object of this report are mentioned in the previous chapter "REPORT OF STRUCTURAL CALCULATION" "ANALYSIS AND CHECKS CARRIED OUT WITH THE AID OF CALCULATION CODES". Where in the following chapters are referenced legislation prior to DM 01/14/08 is due or a simulated design of the existing building or to the requirements of Section 2.7 of Ministerial Decree 14/01/08.

1.3 SIMULATION OF MATERIALS

1.3.1 LEGEND OF MATERIAL DATA TABLE

The program allows to utilize various materials. The material types foreseen by the program are listed below:

1	material of r.c. type
2	material of steel type
3	material of masonry type
4	material of wooden type
5	material of general type

The materials utilized in the present simulation are identifiable by means of identification symbol and numerical code (the latter is actually indicated in the description of the structural elements). The table shows the following data for each material:

Young	modulus of normal elasticity
Poisson	transversal shrinkage factor
G	modulus of tangential elasticity
Gamma	specific weight
Alfa	thermal expansion factor

The above stated data are utilized to simulate the static performance and to determine inertial and thermal loads.

Following data are indicated for the materials of type:

1	***r.c.***		
		Rck	cubic specific strength
		Fctm	average simple tensile strength
2	***steel***		
		Ft	breaking tensile strength
		Fy	yield tension
		Fd	estimated strength
		Fdt	estimated strength for thickness t>40 mm
		Sadm	allowed tension
		Sadmt	allowed tension for thickness t>40 mm
3	***masonry***		
		Resist. Fk	characteristic compression strength
		Resist. Fvko	characteristic shear strength
4	***wood***		
		Resist. comp.	compression allowed strength
		Resist. traz.	tensile allowed tension strength
		Resist. fless.	bending allowed strength
		Resist. tau	shear allowed strength
		Lamellar	lamellar or massive

MATERIAL DATA TABLE

Id	Type / Notes		Young	Poisson	G	Gamma	High
		daN/cm2	daN/cm2		daN/cm2	daN/cm3	
10	STEEL Fe360 - S235		2.100e+06	0.30	8.077e+05	7.80e-03	1.20e-05
	ft	3600.0					
	fy	2350.0					
	fd	2350.0					
	fdt	2100.0					
	sadm	1600.0					
	sadmt	1400.0					

Steel truss	1/7/..	2/8/..	3/9/..	4/10/..	5/11/..	6/12/..
General data						
Beta assigned	0.80					
Verify as a brace	No					
Use conditions I and II	Yes					
Gamma coefficient M0	1.05					
Gamma coefficient M1	1.05					
Gamma coefficient M2	1.25					

Steel columns	1/7/..	2/8/..	3/9/..	4/10/..	5/11/..	6/12/..
Buckling lenghts						
2-2 calculation method	Assigned					
2-2 beta assigned	2.00					
2-2 beta * L assigned [cm]	0.0					
3-3 calculation method	Assigned					
3-3 beta assigned	2.00					
3-3 beta * L assigned [cm]	0.0					
1-1 beta assigned	1.00					
1-1 beta * L assigned [cm]	0.0					
General data						
Gamma coefficient M0	1.05					
Gamma coefficient M1	1.05					
Gamma coefficient M2	1.25					
2nd order effects	Yes					
Eq. moments	Yes					
Use conditions I and II	Yes					

Steel beams	1/7/..	2/8/..	3/9/..	4/10/..	5/11/..	6/12/..
Buckling lenghts						
3-3 beta*L automatic	Yes					
3-3 beta assigned	1.00					
3-3 beta assigned [cm]	0.0					
2-2 beta*L automatic	Yes					
2-2 beta assigned	1.00					
2-2 beta * L assigned [cm]	0.0					
1-1 beta*L automatic	Yes					
1-1 beta assigned	1.00					
1-1 beta * L assigned [cm]	0.0					

Steel beams	1/7/..	2/8/..	3/9/..	4/10/..	5/11/..	6/12/..
General data						
Gamma coefficient M0	1.05					
Gamma coefficient M1	1.05					
Gamma coefficient M2	1.25					
Shear legth for GR [cm]	1.00					
Use conditions I and II	Yes					
Eq. moments	Yes					

WELDED BONDINGS		
Welded joints on perimeter tobe done of class II and extended for the whole perimeter; width of the welding has not less than 2cm	2	cm
Electrodes are E44, class 2,3,4 accordingly to UNI 5132-1974.		
Welded joint have to be done avoiding ANY defect at vertex before of starting up the second welding. Visive inspection of welding has to reveal regularity.		

Welded Joints

BOLTED JUNCTIONS

Bolts screws and nuts has to be conforma to UNI EN ISO 4016:2002 and UNI 5592:1968, and belong to the class of resistence indicated in UNI EN ISO 898-1:2001;
In this structure bolts screws and nuts will belong to class 8.8 for screws and 8 for nuts

Tabella 1 Collegamenti bullonati

All the data here embedded regarding material are indeed used to perform modeling of static scheme and for the determination of inertial and thermal loads. Refering to the kind of material are reporded moreover:

1	*Reinforced concrete*		
		Rck	Cubic caracteristic resistance
		Fctm	Average traction resistance
2	*Steel*		
		Ft	Ultimate tensile stress
		Fy	Yelding tensile stress
		Fd	Calcolous resistence
		Fdt	Calcolous resistence for thickness. t>40 mm
		Sadm	Admissible tensile stress
		Sadmt	Admissible tensile stress for thickness t>40 mm
3	*Masonry*		
		Resist. Fk	Compression strenght
		Resist. Fvko	Shear stress resistence
4	*Wood*		
		Resist. fc0k	Caracteristic resistence (admissible tensile stress for REGLES) for compression
		Resist. ft0k	Caracteristic resistence (admissible tensile stress for REGLES) for traction
		Resist. fmk	Caracteristic resistence (admissible tensile stress for REGLES) for bending
		Resist. fvk	Caracteristic resistence (admissible tensile stress for REGLES) for shear
		Modulo E0.05	Parallel Young modulus

Lamellar	lamellar o massive

Refferring to " **Documento di Affidabilità** *"Test di validazione del software di calcolo PRO_SAP e dei moduli aggiuntivi PRO_SAP Modulo Geotecnico, PRO_CAD nodi acciaio e PRO_MST" -* versione Maggio 2011, disponibile per il download sul sito **www.2si.it**, can be check and download even these softwares:

Modellazione di strutture in acciaio

Test N°	Titolo
55	Verification of stability for compressed steel beam – omega method
56	Free bending strain for beams in steel
57	Free bending strain for columns in steel
58	Twist of steel column
59	Structure Factos
60	STEEL D.M.2008
61	STEEL EC3
62	Hyerarchy of resiststence for structures in steel
63	Stability of compesed beams in steel
73	Links in steel: knot-beam-column flanged within transverse stiffeners
74	Links in steel: knot-beam-column flanged within plate stiffened welded to web of column
75	Links in steel: knot-beam-column flanged within 2 plate stiffened welded to web of column
76	Links in steel: knot-beam-column flanged within 2 plate stiffened welded to wings of column
77	Links in steel: knot-beam-column flanged within 2 plate stiffened welded to wings of column in 2 loading condition
78	Links in steel: knot-beam-column flanged on web without stiffeners bolted on 2 row for both of wings
79	Verification of the link late knot beam and culumn
85	Steel framework with symmetric bracing

1.4 SIMULATION OF SECTIONS

1.4.1 LEGEND OF SECTION DATA TABLE

The program allows to use various sections. The following section types are provided:

- **1** section of general type
- **2** simple steel sections
- **3** special and coupled steel sections

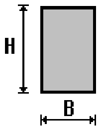
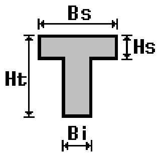
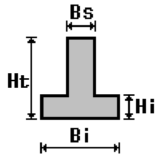
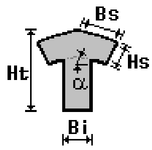
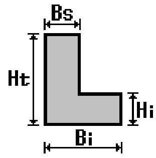
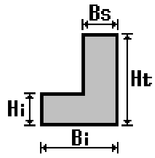
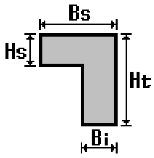
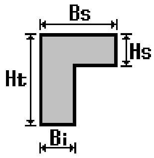
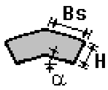
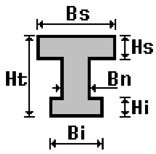
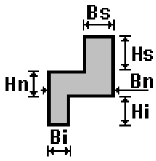
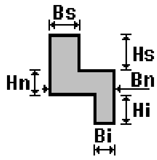
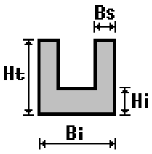
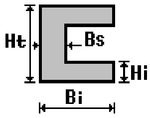
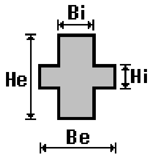
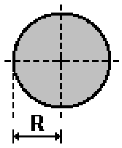
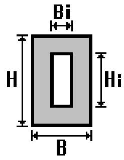
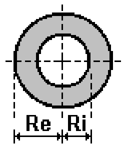
The sections utilized for simulation are identifiable by means of reference symbol and numerical code (the latter is actually indicated in the description of the structural elements).

For each section the following data are indicated in the table:

Area	section area
A V2	section area/shear factor for shear in direction 2
A V3	section area/shear factor for shear in direction 3
Jt	stiffness torsional factor
J2-2	moment of inertia of the section referred to axis 2
J3-3	moment of inertia of the section referred to axis 3
W2-2	section modulus referred to axis 2
W3-3	section modulus referred to axis 3
Wp2-2	plastic section modulus referred to axis 2
Wp3-3	plastic section modulus referred to axis 3

The above data are utilized to determine the inertia loads and to define the structural element stiffness; whenever the value of Area V2 (and/or Area V3) is zero, the deformation for shear V2 (and/or V3) is negligible.

The inertial section characteristics are estimated within element reference 2-3.

 rectangular	 T	 reverse T	 top T	 L	 mirrored L
 mirrored reverse L	 reverse L	 top L	 double T	 mirrored four	 four
 U	 C	 cross	 circular	 hollow rectangular	 hollow circular

About the simple and coupled sections, reference axis 3 coincides with the axis x, according to the most widely known section reference charts.

About the general type sections (type 1):

the dimensional values labeled with B refer to the axis 2

the dimensional values labeled with H refer to the axis 3

Id	Type	Area	A V2	A V3	Jt	J 2-2	J 3-3	W 2-2	W 3-3	Wp 2-2	Wp 3-3
		cm2	cm2	cm2	cm4	cm4	cm4	cm3	cm3	cm3	cm3
1	HEB 200	78.10	0.0	0.0	59.30	2003.00	5696.00	200.30	569.60	305.80	642.50
2	HEB 100	26.00	0.0	0.0	9.20	167.00	450.00	33.50	89.90	51.40	104.20

1.5 METALLIC PROFILATES PECULIARITIES

Column here used are standerd HEB profiles of the series HEB100 and 200. Their peculiarities can be founded in normative and on the internet.

Material is Steel **S 235 (ex Fe 360 B),** cold forged

1.6 SIMULATION OF STRUCTURE: NODES

1.6.1 LEGEND OF NODES DATA TABLE

The program utilizes the structural node.

Each node is identifiable by Cartesian coordinates in the global reference system (X Y Z).

Appropriate code of stiff constraint, code of special foundation and a set of 6 springs (three for displacement and three for rotation) are assigned to each node. The table below shows the above indicated possibilities. In particular the table indicates the following data for each node:

Nodo	node number
X	X coordinate value (idem Y and Z).
Note	six values relative to 6 degrees of freedom foreseen for the node TxTyTzRxRyRz, value 1 indicates that displacement or rotation in question is fixed, value 0 indicates that the displacement and rotation in question is free.
Note	(FS = 1, 2,...) special foundation type code (1, 2,... is referred to these types: isolated foundations, piles, isolated foundations on piles,...) associated to the node.
Rig. TX	stiffness value attributed to elastic constrain eventually applied to the node, i.e. TX (idem TY, TZ, RX, RY, RZ).

NODES DATA TABLE

Node	X	Y	Z	Node	X	Y	Z	Node	X	Y	Z
	cm	cm	cm		cm	cm	cm		cm	cm	cm
3	0.0	-155.0	280.0	4	0.0	155.0	280.0	5	0.0	155.0	560.0
6	0.0	-155.0	560.0	9	-500.0	-155.0	280.0	10	-500.0	155.0	280.0
11	-500.0	155.0	560.0	12	-500.0	-155.0	560.0	15	-1000.0	-155.0	280.0
16	-1000.0	155.0	280.0	17	-1000.0	155.0	560.0	18	-1000.0	-155.0	560.0
21	-1500.0	-155.0	280.0	22	-1500.0	155.0	280.0	23	-1500.0	155.0	560.0
24	-1500.0	-155.0	560.0	25	-100.0	-155.0	280.0	26	-100.0	155.0	280.0
27	-200.0	-155.0	280.0	28	-200.0	155.0	280.0	29	-300.0	-155.0	280.0
30	-300.0	155.0	280.0	31	-400.0	-155.0	280.0	32	-400.0	155.0	280.0
33	-600.0	-155.0	280.0	34	-600.0	155.0	280.0	35	-700.0	-155.0	280.0
36	-700.0	155.0	280.0	37	-800.0	-155.0	280.0	38	-800.0	155.0	280.0
39	-900.0	-155.0	280.0	40	-900.0	155.0	280.0	41	-1100.0	-155.0	280.0
42	-1100.0	155.0	280.0	43	-1200.0	-155.0	280.0	44	-1200.0	155.0	280.0
45	-1300.0	-155.0	280.0	46	-1300.0	155.0	280.0	47	-1400.0	-155.0	280.0
48	-1400.0	155.0	280.0	49	-100.0	-155.0	560.0	50	-100.0	155.0	560.0
51	-200.0	-155.0	560.0	52	-200.0	155.0	560.0	53	-300.0	-155.0	560.0
54	-300.0	155.0	560.0	55	-400.0	-155.0	560.0	56	-400.0	155.0	560.0
57	-600.0	-155.0	560.0	58	-600.0	155.0	560.0	59	-700.0	-155.0	560.0
60	-700.0	155.0	560.0	61	-800.0	-155.0	560.0	62	-800.0	155.0	560.0
63	-900.0	-155.0	560.0	64	-900.0	155.0	560.0	65	-1100.0	-155.0	560.0
66	-1100.0	155.0	560.0	67	-1200.0	-155.0	560.0	68	-1200.0	155.0	560.0
69	-1300.0	-155.0	560.0	70	-1300.0	155.0	560.0	71	-1400.0	-155.0	560.0
72	-1400.0	155.0	560.0								

Node	X	Y	Z	Notes	Stiff. TX	Stiff. TY	Stiff. TZ	Stiff. RX	Stiff. RY	Stiff. RZ
	cm	cm	cm		daN/cm	daN/cm	daN/cm	daN cm/rad	daN cm/rad	daN cm/rad
1	0.0	-155.0	0.0	v=111111						
2	0.0	155.0	0.0	v=111111						
7	-500.0	-155.0	0.0	v=111111						
8	-500.0	155.0	0.0	v=111111						
13	-1000.0	-155.0	0.0	v=111111						
14	-1000.0	155.0	0.0	v=111111						
19	-1500.0	-155.0	0.0	v=111111						
20	-1500.0	155.0	0.0	v=111111						

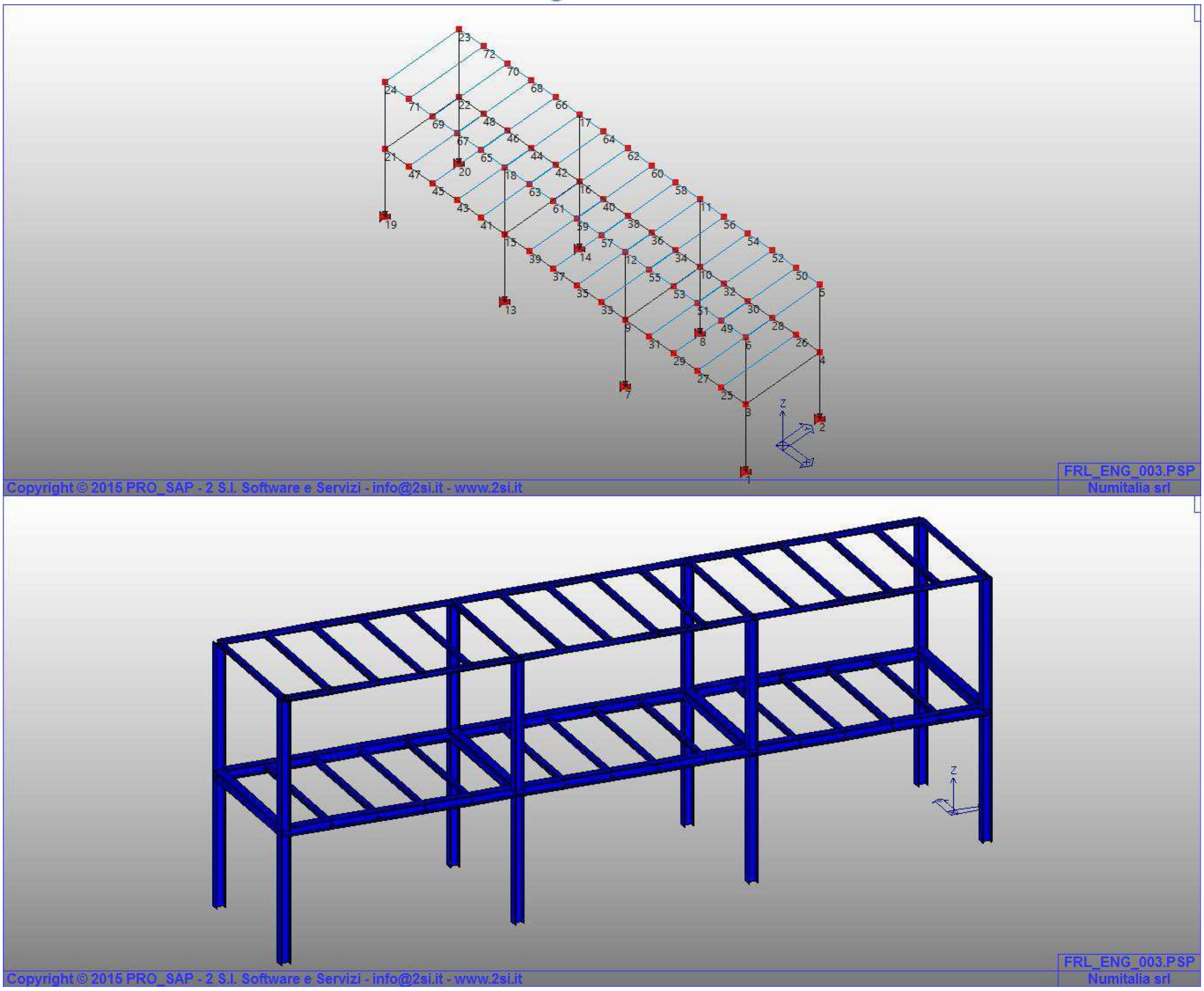


Figure 1: Model of structure and nodes numbering

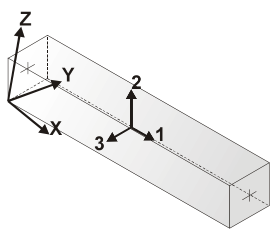
1.7 STRUCTURE SIMULATION: BEAM ELEMENTS

1.7.1 LEGEND OF BEAM DATA TABLE

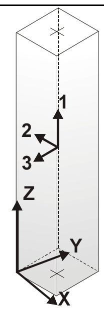
The program utilizes the two-node elements which are generally known as beams.

Each beam element is identifiable by its initial node and final node.

Each element is characterized by a set of properties indicated in the table and required to complete its simulation.



non vertical 2D element orientation



vertical 2D element orientation

In particular each element has the following data:

Elem.	element number
Note	behavior code: beam, foundation beam, pillar, truss, stretched truss, compressed truss, cable-pulley
Nodo I (J)	initial (final) node number
Mat.	material code assigned to the element
Sez.	section code assigned to the element
Rotaz.	value of element rotation around its axis (in case of impossibility to adopt the default orientation). For non-vertical elements the default orientation provides the axis 2 within the vertical plane, and the axis 3 within the horizontal plane, for vertical elements the axis 2 is directed according to negative X, the axis 3 is directed according to negative Y.
Svincolo I (J)	codes for internal actions; the first six codes refer to the initial node, the remaining six refer to the final node (value 1 indicates that the relative internal action is not active).
Wink V	Winkler factor to simulate the beam on the elastic soil within the frames of static analysis
Wink O	Winkler factor to simulate horizontal elastic soil

Elem.	Notes	Node I	Node J	Mat.	Sect.	Rotaz. degrees	Discon. I	Discon. I	Wink V daN/cm3	Wink O daN/cm3
1	Pill.	1	3	10	1					
2	Pill.	3	6	10	1					
3	Pill.	2	4	10	1					
4	Pill.	4	5	10	1					
5	Pill.	8	10	10	1					
6	Pill.	10	11	10	1					
7	Pill.	7	9	10	1					
8	Pill.	9	12	10	1					
9	Pill.	13	15	10	1					
10	Pill.	14	16	10	1					
11	Pill.	16	17	10	1					
12	Pill.	15	18	10	1					
13	Pill.	19	21	10	1					
14	Pill.	20	22	10	1					
15	Pill.	22	23	10	1					
16	Pill.	21	24	10	1					
17	Beam	21	22	10	1					
18	Beam	15	16	10	1					
19	Beam	9	10	10	1					
20	Beam	3	4	10	1					
21	Beam	25	3	10	1					
22	Beam	27	25	10	1					
23	Beam	29	27	10	1					
24	Beam	31	29	10	1					
25	Beam	9	31	10	1					
26	Beam	26	4	10	1					
27	Beam	28	26	10	1					
28	Beam	30	28	10	1					
29	Beam	32	30	10	1					
30	Beam	10	32	10	1					
31	Beam	33	9	10	1					
32	Beam	35	33	10	1					
33	Beam	37	35	10	1					
34	Beam	39	37	10	1					
35	Beam	15	39	10	1					
36	Beam	41	15	10	1					
37	Beam	43	41	10	1					
38	Beam	45	43	10	1					
39	Beam	47	45	10	1					
40	Beam	21	47	10	1					
41	Beam	34	10	10	1					
42	Beam	36	34	10	1					
43	Beam	38	36	10	1					
44	Beam	40	38	10	1					
45	Beam	16	40	10	1					
46	Beam	42	16	10	1					
47	Beam	44	42	10	1					
48	Beam	46	44	10	1					
49	Beam	48	46	10	1					
50	Beam	22	48	10	1					
51	Beam	25	26	10	2					
52	Beam	27	28	10	2					
53	Beam	29	30	10	2					
54	Beam	31	32	10	2					
55	Beam	33	34	10	2					
56	Beam	35	36	10	2					
57	Beam	37	38	10	2					
58	Beam	39	40	10	2					
59	Beam	41	42	10	2					
60	Beam	43	44	10	2					
61	Beam	45	46	10	2					
62	Beam	47	48	10	2					
63	Beam	50	5	10	2					
64	Beam	52	50	10	2					
65	Beam	54	52	10	2					
66	Beam	56	54	10	2					
67	Beam	11	56	10	2					
68	Beam	58	11	10	2					
69	Beam	60	58	10	2					
70	Beam	62	60	10	2					
71	Beam	64	62	10	2					

72	Beam	17	64	10	2
73	Beam	66	17	10	2
74	Beam	68	66	10	2
75	Beam	70	68	10	2
76	Beam	72	70	10	2
77	Beam	23	72	10	2
78	Beam	6	5	10	2
79	Beam	12	11	10	2
80	Beam	18	17	10	2
81	Beam	24	23	10	2
82	Beam	24	71	10	2
83	Beam	71	69	10	2
84	Beam	69	67	10	2
85	Beam	67	65	10	2
86	Beam	65	18	10	2
87	Beam	18	63	10	2
88	Beam	63	61	10	2
89	Beam	61	59	10	2
90	Beam	59	57	10	2
91	Beam	57	12	10	2
92	Beam	12	55	10	2
93	Beam	55	53	10	2
94	Beam	53	51	10	2
95	Beam	51	49	10	2
96	Beam	49	6	10	2
97	Beam	49	50	10	2
98	Beam	51	52	10	2
99	Beam	53	54	10	2
100	Beam	55	56	10	2
101	Beam	57	58	10	2
102	Beam	59	60	10	2
103	Beam	61	62	10	2
104	Beam	63	64	10	2
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108	Beam	69	70	10	2

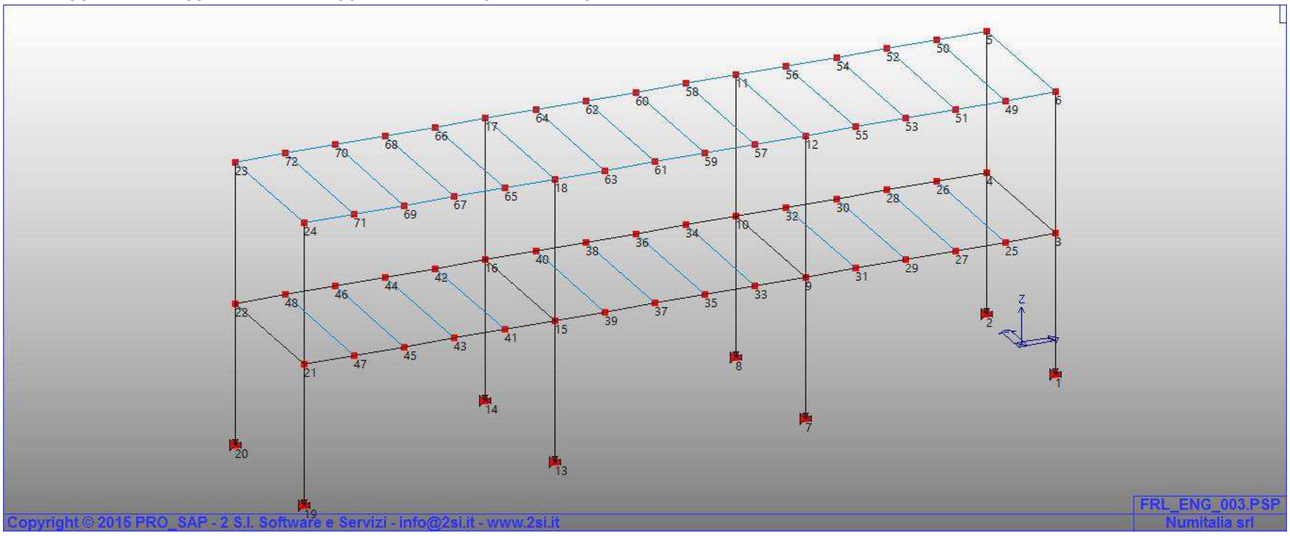


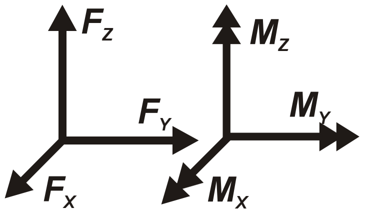
Figure 2: Constraints modeling

1.8 LOAD MODELLING

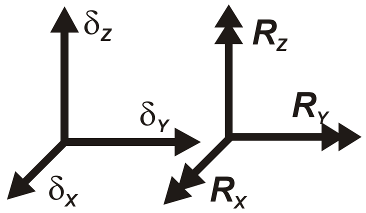
1.8.1 LEGEND OF DATA LOAD TABLE

The present program allows the simulation of several types of load. The modeling loads have a symbol and a numeric identification code (in their description the structural elements refer to the numeric one).
Appropriate code, type and identification symbol are assigned to each load applied to the structure.
The tables below detail the typical values for each type of load.
Referring to the type, the tables actually show the following data:

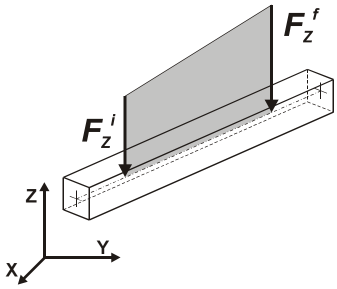
1	nodal concentrated load 6 values (force Fx, Fy, Fz, moment Mx, My, Mz)
2	nodal imposed displacement 6 values (displacement Tx,Ty,Tz, rotation Rx,Ry,Rz)
3	global distributed load on a beam type element 7 values (fx,fy,fz,mx,my,mz, initial position of load application) 7 values (fx,fy,fz,mx,my,mz, final position of load application)
4	local distributed load on a beam type element 7 values (f1,f2,f3,m1,m2,m3,initial position of load application) 7 values (f1,f2,f3,m1,m2,m3,final position of load application)
5	global concentrated load on a beam type element 7 values (Fx,Fy,Fz,Mx,My,Mz, load position)
6	local concentrated load on a beam type element 7 values (F1, F2, F3, M1, M2, M3, load position)
7	temperature change applied on a beam type element 7 values (temperature changes: uniform, average temperature change at the initial and final node - temperature change as per height and width of the section of the initial and final node)
8	uniform pressure load on a plate type element 1 value (pressure)
9	variable pressure load on a plate type element 4 values (pressure, quote, pressure, quote)
10	temperature change applied to a plate type element 2 values (temperature changes: average temperature change and temperature change through the thickness)
11	generic variable load on plate/shell and beam type elements 1 value for typology description 1 values for each segment where the function is defined (position, value, position, value) the typology specifies the abscissas of the definition domain, the direction of load, the loading mode and the influence width for beam type elements.
12	group of loads on plate/shell area 9 values (number of loads in X and Y direction, value of single force, center of first force, dimension of area and distance in X and Y of loads.



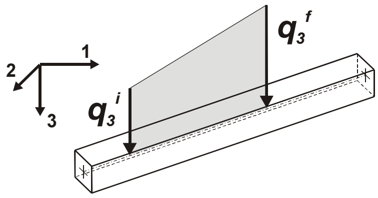
nodal concentrated load



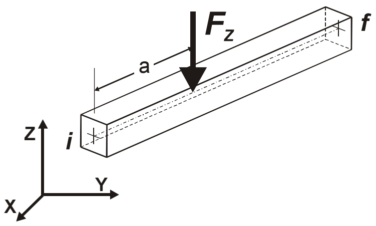
nodal imposed displacement



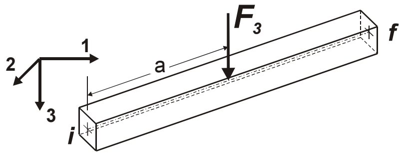
global distributed load on a beam type element



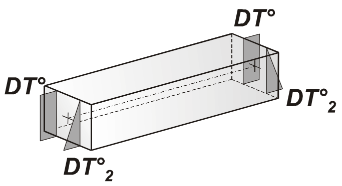
local distributed load on a beam type element



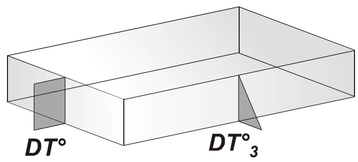
global concentrated load on a beam type element



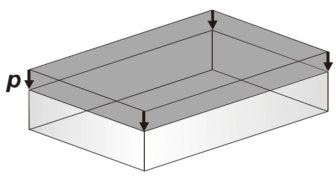
local concentrated load on a beam type element



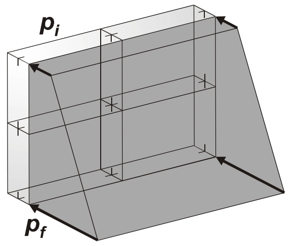
temperature change applied on a beam type element



uniform pressure load on a plate type element



uniform pressure load on a plate type element



variable pressure load on a plate type element

Type	global distributed load on beam

Id	Type	Pos.	fx	fy	fz	mx	my	mz
		cm	daN/cm	daN/cm	daN/cm	daN	daN	daN
2	p4HEB100solaio	0.0	0.0	0.0	-4.35	0.0	0.0	0.0
		310.00	0.0	0.0	-4.35	0.0	0.0	0.0
3	p3HEB200solaio	0.0	0.0	0.0	-13.00	0.0	0.0	0.0
		310.00	0.0	0.0	-13.00	0.0	0.0	0.0
4	p2	0.0	0.0	0.0	-8.13	0.0	0.0	0.0
		310.00	0.0	0.0	-8.13	0.0	0.0	0.0
5	p1	0.0	0.0	0.0	-8.40	0.0	0.0	0.0
		100.00	0.0	0.0	-8.40	0.0	0.0	0.0

Loads here defined consist of:

p1=distribuited load due to the weight of the closing bricks at the first floor appling on the longitudinal perimeter of the structure

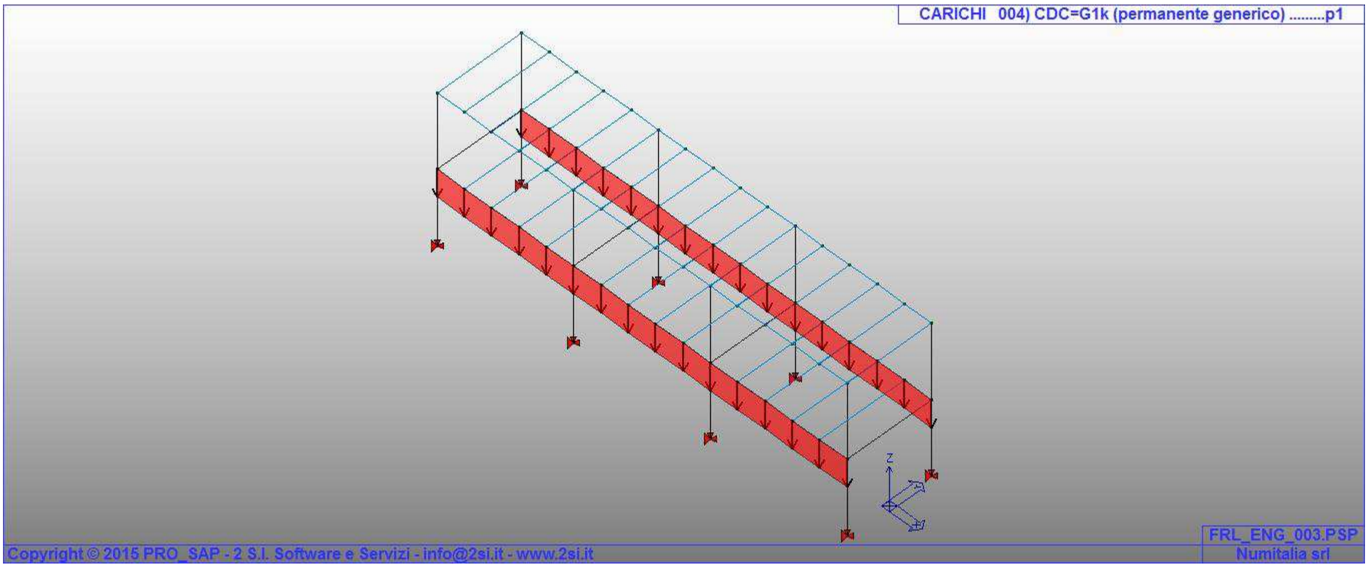
p2= distribuited load due to the weight of the closing bricks at the first floor appling on the transverse perimeter of the structure

p3HEB200solaio=load of the floor and tiles loading the main structure

p4HEB100solaio=load of the floor and tiles loading secondary structure

All these loads are considered multiplied by a safety factor of 1.5

In order to better understand their nature please check out the following pictures
Due to the negligibility of the load due to the roof, it has been decided not to consider it as a source of stress and strain for the structure.
On the other hand the weight of the structure is considerated intrinsecally.



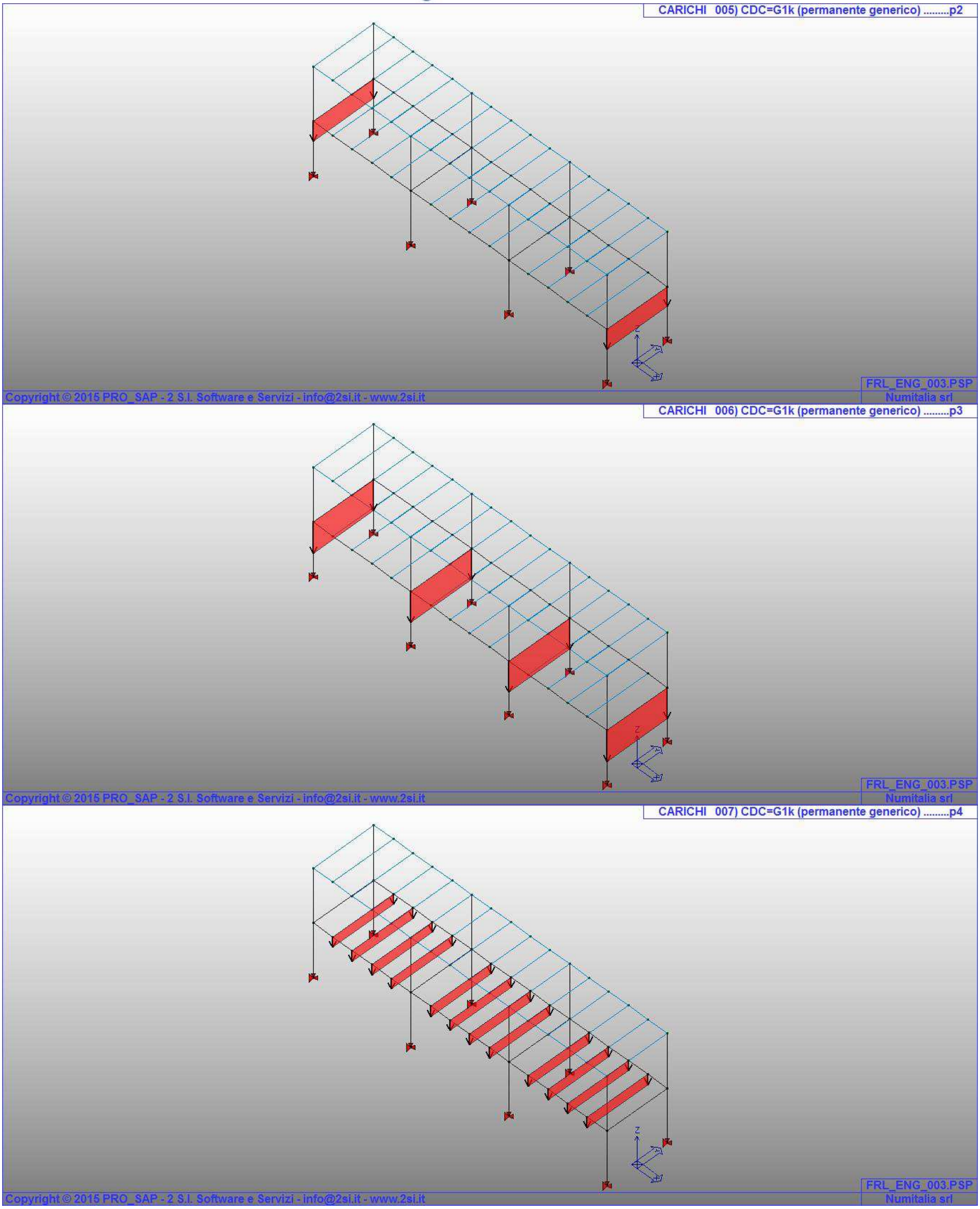


Figure 3: Loads modeling

Concerning SEISMIC LOADS due to the installation site geologic characteristic, due to its geological history and on top of that accordingly to specific normative:

1. UNI EN 1997-1:2005 01/02/2005 Eurocodice 7 - Progettazione geotecnica - Parte 1: Regole generali.
2. UNI EN 1998-1:2005 01/03/2005 Eurocodice 8 - Progettazione delle strutture per la resistenza sismica - Parte 1: Regole generali, azioni sismiche e regole per gli edifici.
3. UNI EN 1998-3:2005 01/08/2005 Eurocodice 8 - Progettazione delle strutture per la resistenza sismica - Parte 3: Valutazione e adeguamento degli edifici.

   UNI EN 1998-5:2005 01/01/2005 Eurocodice 8 - Progettazione delle strutture per la resistenza sismica - Parte 5: Fondazioni, strutture di contenimento ed aspetti geotecnici.

Seismic load can be considered NEGLIGIBLE

1.9 LOAD CASE SCHEMATIZATION

1.9.1 LEGEND OF LOAD CASE TABLE

The program allows the usage of various load cases.

The following 11 load cases are considered:

	Name	***Type***	***Description***
1	**Ggk**	A	load case including the structure dead weight
2	**Gk**	NA	load case including permanent loads
3	**Qk**	NA	load case including live loads
4	**Gsk**	A	load case including floor and roof permanent loads
5	**Qsk**	A	load case including floor and roof live loads
6	**Qnk**	A	load case including roof snow live loads
7	**Qtk**	SA	load case including structure temperature change
8	**Qvk**	NA	load case including structure wind loads
9	**Esk**	SA	seismic load case by the way of the equivalent static analysis
10	**Edk**	SA	seismic load case by the way of the dynamic analysis
11	**Etk**	NA	load case including forces due to earth pressure seismic increment
12	**Pk**	NA	load case including loads due to constraints subsiding, and prestressing.

The automatic (A) load cases (i.e. the user won't be asked to enter data) are labeled as:
1-Ggk, 4-Gsk, 5-Qsk, 6-Qnk;

The semi-automatic (SA) load cases (i.e. the user will be asked to enter a minimum part of data) are labeled as:
7-Qtk, (only the temperature change value has to be entered);
9-Esk, 10-Edk, (only the input earthquake direction angle value and the load case identification has to be entered.

The remaining load cases are said non-automatic (NA) load cases (i.e. the user will be asked to enter generic loads for the structural elements).

The below table shows the load cases affecting the structure and their related data, i.e.:
the *Type Number*, the *Identification Code* and the *Load Case Reference Value* (where requested).

For the non-automatic load cases, the loaded nodes and elements are listed (the load identification code is included).

For the seismic load cases (9-Esk and 10-Edk), the input angle values, the seismic intensity, the structure and foundation coefficients are shown; finally, the related mass rate, for each load case participating to the seismic mass definition, is shown.

Let us point out that in the load cases 5-Qsk and 6-Qnk, each floor or roof element in the model is assumed wholly participating to the seismic mass definition (see the Sksol value in the floor element chapter) and therefore, their participating mass rate is assumed to be 1.

L.C.	Type	Code Id	Notes
1	Ggk	CDC=Ggk (peso proprio della struttura)	
4	Gk	CDC=G1k (permanente generico) p1	D2 :from 21 to 50 Action : p1
5	Gk	CDC=G1k (permanente generico) p2	D2 : 17 Action : p2
			D2 : 20 Action : p2
6	Gk	CDC=G1k (permanente generico) p3	D2 : 17 Action : p3HEB200solaio
			D2 :from 18 to 19 Action : p3HEB200solaio
			D2 : 20 Action : p3HEB200solaio
7	Gk	CDC=G1k (permanente generico) p4	D2 :from 51 to 62 Action : p4HEB100solaio

1.10LOAD COMBINATION DEFINITION

1.10.1 LEGEND OF LOAD COMBINATION DEFINITION TABLE

The program combines various load case types according to the regulations foreseen by the acting standards and norms currently in force.

The foreseen combinations are provided for the structure safety control, in the course of which the structure resistance to displacements and stresses is checked.

The below presented load combination table shows the following data:

Type Number and *Identification Symbol*

The table below shows the load cases affecting the structure and involved in the load combination, each one with respective own weight.

Cmb	Type	Code Id	effect P-delta
1	SLU	Comb. SLU A1 1	
2	SLU	Comb. SLU A1 2	
3	SLS(r)	Comb. SLE(rara) 3	
4	SLU	Comb. SLU A1 (SLV sism.) 4	
5	SLU	Comb. SLU A1 (SLV sism.) 5	
6	SLU	Comb. SLU A1 (SLV sism.) 6	
7	SLU	Comb. SLU A1 (SLV sism.) 7	
8	SLU	Comb. SLU A1 (SLV sism.) 8	
9	SLU	Comb. SLU A1 (SLV sism.) 9	
10	SLU	Comb. SLU A1 (SLV sism.) 10	
11	SLU	Comb. SLU A1 (SLV sism.) 11	
12	SLU	Comb. SLU A1 (SLV sism.) 12	
13	SLU	Comb. SLU A1 (SLV sism.) 13	
14	SLU	Comb. SLU A1 (SLV sism.) 14	
15	SLU	Comb. SLU A1 (SLV sism.) 15	
16	SLU	Comb. SLU A1 (SLV sism.) 16	
17	SLU	Comb. SLU A1 (SLV sism.) 17	
18	SLU	Comb. SLU A1 (SLV sism.) 18	
19	SLU	Comb. SLU A1 (SLV sism.) 19	
20	SLU	Comb. SLU A1 (SLV sism.) 20	
21	SLU	Comb. SLU A1 (SLV sism.) 21	
22	SLU	Comb. SLU A1 (SLV sism.) 22	
23	SLU	Comb. SLU A1 (SLV sism.) 23	
24	SLU	Comb. SLU A1 (SLV sism.) 24	
25	SLU	Comb. SLU A1 (SLV sism.) 25	
26	SLU	Comb. SLU A1 (SLV sism.) 26	
27	SLU	Comb. SLU A1 (SLV sism.) 27	
28	SLU	Comb. SLU A1 (SLV sism.) 28	
29	SLU	Comb. SLU A1 (SLV sism.) 29	
30	SLU	Comb. SLU A1 (SLV sism.) 30	
31	SLU	Comb. SLU A1 (SLV sism.) 31	
32	SLU	Comb. SLU A1 (SLV sism.) 32	
33	SLU	Comb. SLU A1 (SLV sism.) 33	
34	SLU	Comb. SLU A1 (SLV sism.) 34	
35	SLU	Comb. SLU A1 (SLV sism.) 35	
36	SLD(seism.)	Comb. SLE (SLD Danno sism.) 36	
37	SLD(seism.)	Comb. SLE (SLD Danno sism.) 37	
38	SLD(seism.)	Comb. SLE (SLD Danno sism.) 38	
39	SLD(seism.)	Comb. SLE (SLD Danno sism.) 39	
40	SLD(seism.)	Comb. SLE (SLD Danno sism.) 40	
41	SLD(seism.)	Comb. SLE (SLD Danno sism.) 41	
42	SLD(seism.)	Comb. SLE (SLD Danno sism.) 42	
43	SLD(seism.)	Comb. SLE (SLD Danno sism.) 43	
44	SLD(seism.)	Comb. SLE (SLD Danno sism.) 44	
45	SLD(seism.)	Comb. SLE (SLD Danno sism.) 45	
46	SLD(seism.)	Comb. SLE (SLD Danno sism.) 46	
47	SLD(seism.)	Comb. SLE (SLD Danno sism.) 47	
48	SLD(seism.)	Comb. SLE (SLD Danno sism.) 48	
49	SLD(seism.)	Comb. SLE (SLD Danno sism.) 49	
50	SLD(seism.)	Comb. SLE (SLD Danno sism.) 50	

Cmb	Type	Code Id	effect P-delta
51	SLD(seism.)	Comb. SLE (SLD Danno sism.) 51	
52	SLD(seism.)	Comb. SLE (SLD Danno sism.) 52	
53	SLD(seism.)	Comb. SLE (SLD Danno sism.) 53	
54	SLD(seism.)	Comb. SLE (SLD Danno sism.) 54	
55	SLD(seism.)	Comb. SLE (SLD Danno sism.) 55	
56	SLD(seism.)	Comb. SLE (SLD Danno sism.) 56	
57	SLD(seism.)	Comb. SLE (SLD Danno sism.) 57	
58	SLD(seism.)	Comb. SLE (SLD Danno sism.) 58	
59	SLD(seism.)	Comb. SLE (SLD Danno sism.) 59	
60	SLD(seism.)	Comb. SLE (SLD Danno sism.) 60	
61	SLD(seism.)	Comb. SLE (SLD Danno sism.) 61	
62	SLD(seism.)	Comb. SLE (SLD Danno sism.) 62	
63	SLD(seism.)	Comb. SLE (SLD Danno sism.) 63	
64	SLD(seism.)	Comb. SLE (SLD Danno sism.) 64	
65	SLD(seism.)	Comb. SLE (SLD Danno sism.) 65	
66	SLD(seism.)	Comb. SLE (SLD Danno sism.) 66	
67	SLD(seism.)	Comb. SLE (SLD Danno sism.) 67	

Cmb	CDC 1/15...	CDC 2/16...	CDC 3/17...	CDC 4/18...	CDC 5/19...	CDC 6/20...	CDC 7/21...
1	1.30	0.0	0.0	0.0	0.0	0.0	0.0
2	1.00	0.0	0.0	0.0	0.0	0.0	0.0
3	1.00	0.0	0.0	0.0	0.0	0.0	0.0
4	1.00	-1.00	0.0	-0.30	0.0	0.0	0.0
5	1.00	-1.00	0.0	0.30	0.0	0.0	0.0
6	1.00	1.00	0.0	-0.30	0.0	0.0	0.0
7	1.00	1.00	0.0	0.30	0.0	0.0	0.0
8	1.00	-1.00	0.0	0.0	-0.30	0.0	0.0
9	1.00	-1.00	0.0	0.0	0.30	0.0	0.0
10	1.00	1.00	0.0	0.0	-0.30	0.0	0.0
11	1.00	1.00	0.0	0.0	0.30	0.0	0.0
12	1.00	0.0	-1.00	-0.30	0.0	0.0	0.0
13	1.00	0.0	-1.00	0.30	0.0	0.0	0.0
14	1.00	0.0	1.00	-0.30	0.0	0.0	0.0
15	1.00	0.0	1.00	0.30	0.0	0.0	0.0
16	1.00	0.0	-1.00	0.0	-0.30	0.0	0.0
17	1.00	0.0	-1.00	0.0	0.30	0.0	0.0
18	1.00	0.0	1.00	0.0	-0.30	0.0	0.0
19	1.00	0.0	1.00	0.0	0.30	0.0	0.0
20	1.00	-0.30	0.0	-1.00	0.0	0.0	0.0
21	1.00	-0.30	0.0	1.00	0.0	0.0	0.0
22	1.00	0.30	0.0	-1.00	0.0	0.0	0.0
23	1.00	0.30	0.0	1.00	0.0	0.0	0.0
24	1.00	0.0	-0.30	-1.00	0.0	0.0	0.0
25	1.00	0.0	-0.30	1.00	0.0	0.0	0.0
26	1.00	0.0	0.30	-1.00	0.0	0.0	0.0
27	1.00	0.0	0.30	1.00	0.0	0.0	0.0
28	1.00	-0.30	0.0	0.0	-1.00	0.0	0.0
29	1.00	-0.30	0.0	0.0	1.00	0.0	0.0
30	1.00	0.30	0.0	0.0	-1.00	0.0	0.0
31	1.00	0.30	0.0	0.0	1.00	0.0	0.0
32	1.00	0.0	-0.30	0.0	-1.00	0.0	0.0
33	1.00	0.0	-0.30	0.0	1.00	0.0	0.0
34	1.00	0.0	0.30	0.0	-1.00	0.0	0.0
35	1.00	0.0	0.30	0.0	1.00	0.0	0.0
36	1.00	0.0	0.0	0.0	0.0	-1.00	0.0
37	1.00	0.0	0.0	0.0	0.0	-1.00	0.0
38	1.00	0.0	0.0	0.0	0.0	1.00	0.0
39	1.00	0.0	0.0	0.0	0.0	1.00	0.0
40	1.00	0.0	0.0	0.0	0.0	-1.00	0.0
41	1.00	0.0	0.0	0.0	0.0	-1.00	0.0
42	1.00	0.0	0.0	0.0	0.0	1.00	0.0
43	1.00	0.0	0.0	0.0	0.0	1.00	0.0
44	1.00	0.0	0.0	0.0	0.0	0.0	-1.00
45	1.00	0.0	0.0	0.0	0.0	0.0	-1.00
46	1.00	0.0	0.0	0.0	0.0	0.0	1.00
47	1.00	0.0	0.0	0.0	0.0	0.0	1.00
48	1.00	0.0	0.0	0.0	0.0	0.0	-1.00
49	1.00	0.0	0.0	0.0	0.0	0.0	-1.00
50	1.00	0.0	0.0	0.0	0.0	0.0	1.00
51	1.00	0.0	0.0	0.0	0.0	0.0	1.00
52	1.00	0.0	0.0	0.0	0.0	-0.30	0.0

Cmb	CDC 1/15...	CDC 2/16...	CDC 3/17...	CDC 4/18...	CDC 5/19...	CDC 6/20...	CDC 7/21...
53	1.00	0.0	0.0	0.0	0.0	-0.30	0.0
54	1.00	0.0	0.0	0.0	0.0	0.30	0.0
55	1.00	0.0	0.0	0.0	0.0	0.30	0.0
56	1.00	0.0	0.0	0.0	0.0	0.0	-0.30
57	1.00	0.0	0.0	0.0	0.0	0.0	-0.30
58	1.00	0.0	0.0	0.0	0.0	0.0	0.30
59	1.00	0.0	0.0	0.0	0.0	0.0	0.30
60	1.00	0.0	0.0	0.0	0.0	-0.30	0.0
61	1.00	0.0	0.0	0.0	0.0	-0.30	0.0
62	1.00	0.0	0.0	0.0	0.0	0.30	0.0
63	1.00	0.0	0.0	0.0	0.0	0.30	0.0
64	1.00	0.0	0.0	0.0	0.0	0.0	-0.30
65	1.00	0.0	0.0	0.0	0.0	0.0	-0.30
66	1.00	0.0	0.0	0.0	0.0	0.0	0.30
67	1.00	0.0	0.0	0.0	0.0	0.0	0.30

1.11NODAL ANALYSIS RESULTS

1.11.1 LEGEND OF NODAL ANALYSIS RESULTS

The analysis results of the structural nodes can be controlled on the basis of the below tables.

The first table indicates the nodal displacements for each combination.

The second table indicates the values of the actions exercised by the structure on the constraints (sign inverted constraint reactions) for each node to which special foundation or stiff and/or elastic constraints is attributed and for each combination.

Node	Cmb	X translation	Y translation	Z translation	X rotation	Y rotation	Z rotation
		cm	cm	cm			
1	1	0.0	0.0	0.0	0.0	0.0	0.0
1	2	0.0	0.0	0.0	0.0	0.0	0.0
1	3	0.0	0.0	0.0	0.0	0.0	0.0
...							
72	67	1.38e-03	0.0	-0.04	2.63e-04	5.47e-04	0.0
Node		**X translation**	**Y translation**	**Z translation**	**X rotation**	**Y rotation**	**Z rotation**
		-3.78e-03	-3.15e-04	-0.16	-5.95e-03	-9.59e-04	-3.37e-06
		3.78e-03	3.15e-04	0.13	5.95e-03	9.59e-04	3.37e-06

Node	Cmb	Action X	Action Y	Action Z	Action RX	Action RY	Action RZ
		daN	daN	daN	daN cm	daN cm	daN cm
1	1	45.28	-9.69	-1021.37	904.69	4289.20	-9.40e-03
1	2	34.83	-7.45	-785.67	695.91	3299.38	-7.23e-03
1	3	34.83	-7.45	-785.67	695.91	3299.38	-7.23e-03
...							
20	67	-129.55	8.79	-1165.07	-820.60	-1.208e+04	-6.26e-03
Node		**Action X**	**Action Y**	**Action Z**	**Action RX**	**Action RY**	**Action RZ**
		-444.90	-189.35	-5442.76	-1.766e+04	-4.131e+04	-0.14
		444.90	189.35	3173.72	1.766e+04	4.131e+04	0.14

Node	Cmb	Action X	Action Y	Action Z	Action RX	Action RY	Action RZ
		daN	daN	daN	daN cm	daN cm	daN cm
1	38	34.83	-189.35	-2800.67	1.766e+04	3299.38	0.13
	36	34.83	174.44	1229.33	-1.627e+04	3299.38	-0.14
	36	34.83	174.44	1229.33	-1.627e+04	3299.38	-0.14
	38	34.83	-189.35	-2800.67	1.766e+04	3299.38	0.13
	20	-375.23	-7.45	1206.09	695.91	-3.471e+04	-7.23e-03
	21	444.90	-7.45	-2777.42	695.91	4.131e+04	-7.23e-03
2	38	34.83	189.35	-2800.67	-1.766e+04	3299.38	-0.13
	36	34.83	-174.44	1229.33	1.627e+04	3299.38	0.14
	38	34.83	189.35	-2800.67	-1.766e+04	3299.38	-0.13
	36	34.83	-174.44	1229.33	1.627e+04	3299.38	0.14
	20	-375.23	7.45	1206.09	-695.91	-3.471e+04	7.23e-03
	21	444.90	7.45	-2777.42	-695.91	4.131e+04	7.23e-03
7	21	-46.31	-7.63	-5442.76	712.18	-4386.51	0.0
	20	41.25	-7.63	3173.72	712.18	3946.61	0.0
	36	-2.53	173.82	880.48	-1.621e+04	-219.95	-7.26e-06
	38	-2.53	-189.07	-3149.52	1.764e+04	-219.95	6.43e-06
	21	-46.31	-7.63	-5442.76	712.18	-4386.51	0.0
	20	41.25	-7.63	3173.72	712.18	3946.61	0.0
8	21	-46.31	7.63	-5442.76	-712.18	-4386.51	0.0
	20	41.25	7.63	3173.72	-712.18	3946.61	0.0
	38	-2.53	189.07	-3149.52	-1.764e+04	-219.95	-6.43e-06
	36	-2.53	-173.82	880.48	1.621e+04	-219.95	7.26e-06
	21	-46.31	7.63	-5442.76	-712.18	-4386.51	0.0
	20	41.25	7.63	3173.72	-712.18	3946.61	0.0
13	21	46.31	-7.63	-5442.76	712.18	4386.51	0.0
	20	-41.25	-7.63	3173.72	712.18	-3946.61	0.0
	36	2.53	173.82	880.48	-1.621e+04	219.95	7.26e-06
	38	2.53	-189.07	-3149.52	1.764e+04	219.95	-6.43e-06
	20	-41.25	-7.63	3173.72	712.18	-3946.61	0.0
	21	46.31	-7.63	-5442.76	712.18	4386.51	0.0
14	21	46.31	7.63	-5442.76	-712.18	4386.51	0.0
	20	-41.25	7.63	3173.72	-712.18	-3946.61	0.0
	38	2.53	189.07	-3149.52	-1.764e+04	219.95	6.43e-06

	36	2.53	-173.82	880.48	1.621e+04	219.95	-7.26e-06
	20	-41.25	7.63	3173.72	-712.18	-3946.61	0.0
	21	46.31	7.63	-5442.76	-712.18	4386.51	0.0
19	38	-34.83	-189.35	-2800.67	1.766e+04	-3299.38	-0.13
	36	-34.83	174.44	1229.33	-1.627e+04	-3299.38	0.14
	36	-34.83	174.44	1229.33	-1.627e+04	-3299.38	0.14
	38	-34.83	-189.35	-2800.67	1.766e+04	-3299.38	-0.13
	21	-444.90	-7.45	-2777.42	695.91	-4.131e+04	7.23e-03
	20	375.23	-7.45	1206.09	695.91	3.471e+04	7.23e-03
20	38	-34.83	189.35	-2800.67	-1.766e+04	-3299.38	0.13
	36	-34.83	-174.44	1229.33	1.627e+04	-3299.38	-0.14
	38	-34.83	189.35	-2800.67	-1.766e+04	-3299.38	0.13
	36	-34.83	-174.44	1229.33	1.627e+04	-3299.38	-0.14
	21	-444.90	7.45	-2777.42	-695.91	-4.131e+04	-7.23e-03
	20	375.23	7.45	1206.09	-695.91	3.471e+04	-7.23e-03

1.12 RESULTS OF BEAM ELEMENT TYPE ANALYSIS

1.12.1 LEGEND OF BEAM ELEMENT TYPE ANALYSIS RESULTS

The results of the beam element type analysis can be controlled on the basis of the below tables.

The elements are grouped in:

- **pillar** type
- **beam** type
- **foundation beam** type

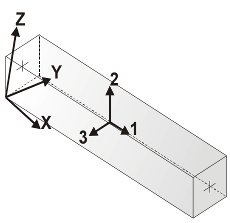
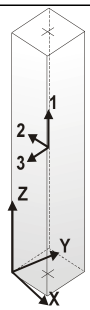
For each element and for each combination the significant results are listed.

For the *pillar* element type are indicated the values as follows:

Pilas.	pillar element number
Cmb	combination related to the listed results
M3 mx/mn	max bending moment at the bay M3 (first row) / min (second row)
M2 mx/mn	max bending moment at the bay M2 (first row) / min (second row)
D2/D3	maximum deflection in direction 2 (first row) / direction 3 (second row)
Q2/Q3	total load in direction 2 (first row) / direction 3 (second row)
Pos.	coordinates of the initial point and final point of the element
N, V2, ecc..	six action components applied to the foot and to the top of the pillar element type

For the *beam* element type the same results of the pillar element type are indicated.

For the *foundation beam* element type the same results of the pillar element type are indicated and the maximum soil pressure is added.

	non vertical 2D element orientation		vertical 2D element orientation

Pill.	Cmb	M3 mx/mn	M2 mx/mn	D 2 / D 3	Q 2 / Q 3	Pos.	N	V 2	V 3	T	M 2	M 3
		daN cm	daN cm	cm	daN	cm	daN	daN	daN	daN cm	daN cm	daN cm
1	1	8390.28	904.69	-2.10e-03	0.0	0.0	-1021.37	45.28	-9.69	-9.40e-03	904.69	-4289.20
		-4289.20	-1807.59	1.23e-03	0.0	70.0	-965.93	45.28	-9.69	-9.40e-03	226.62	-1119.33
						140.0	-910.50	45.28	-9.69	-9.40e-03	-451.45	2050.54
...												
16	67	-1.052e+04	-1565.70	-9.10e-04	0.0	280.0	-144.96	-118.73	-12.75	-0.07	-1565.70	-1.052e+04
Pill.		M3 mx/mn	M2 mx/mn	D 2 / D 3	Q 2 / Q 3		N	V 2	V 3	T		
		-8.326e+04	-3.535e+04	-0.03	0.0		-5442.76	-444.90	-189.35	-0.45		
		8.326e+04	3.535e+04	0.03	0.0		3344.29	444.90	189.35	0.45		

Beam	Cmb	M3 mx/mn	M2 mx/mn	D 2 / D 3	Q 2 / Q 3	Pos.	N	V 2	V 3	T	M 2	M 3
		daN cm	daN cm	cm	daN	cm	daN	daN	daN	daN cm	daN cm	daN cm
17	1	5490.16	1.49	-3.87e-03	-245.50	0.0	5.89	122.75	0.0	0.0	1.49	-4022.95
		-4022.95	1.49	-4.26e-06	0.0	38.8	5.89	92.06	0.0	0.0	1.49	139.03
						77.5	5.89	61.37	0.0	0.0	1.49	3111.88
...												
108	67	-0.22	0.13	-4.33e-06	0.0	310.0	0.02	-31.43	0.0	0.0	0.13	-0.22
Beam		M3 mx/mn	M2 mx/mn	D 2 / D 3	Q 2 / Q 3		N	V 2	V 3	T		
		-2.115e+05	-125.05	-0.57	-4218.85		-282.48	-2436.81	-1.97	-2652.41		
		1.709e+05	125.05	0.52	3841.15		231.88	2436.81	1.97	2652.41		

Here below are reported pictures including Strain deformations due to weight and distribuited load previously defined.

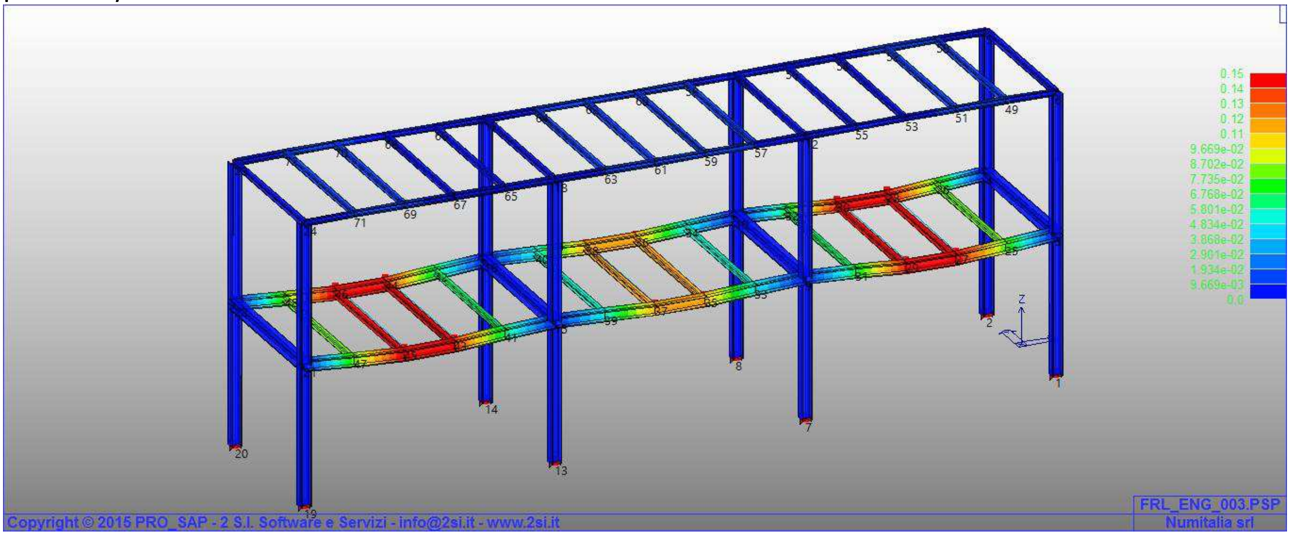


Figure 4: strain due to p1

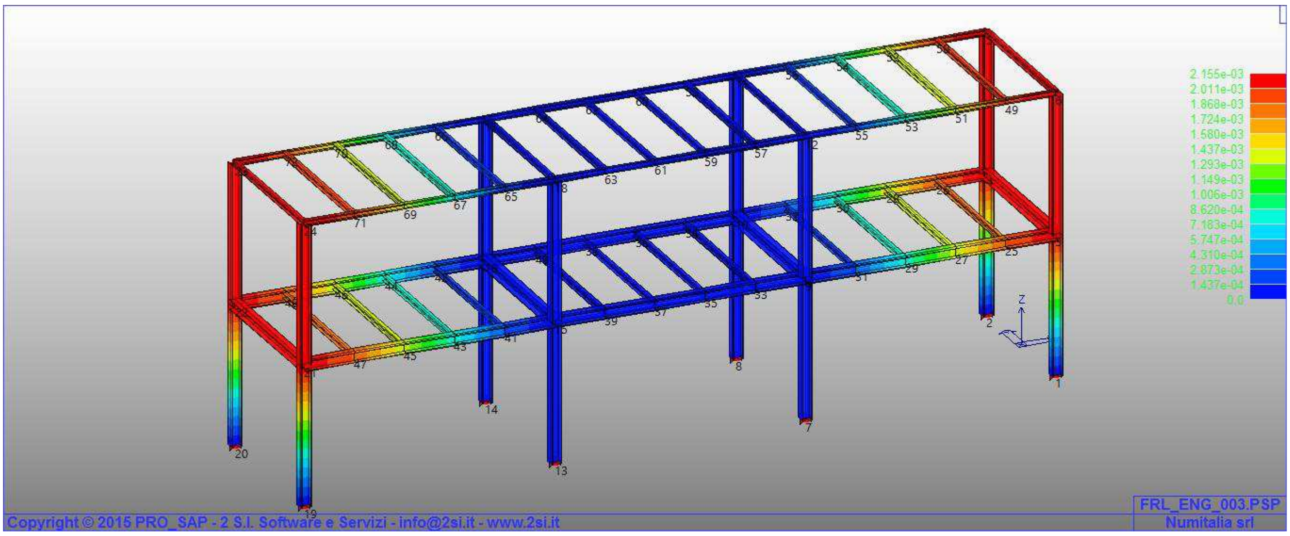


Figure 5: strain due to p2

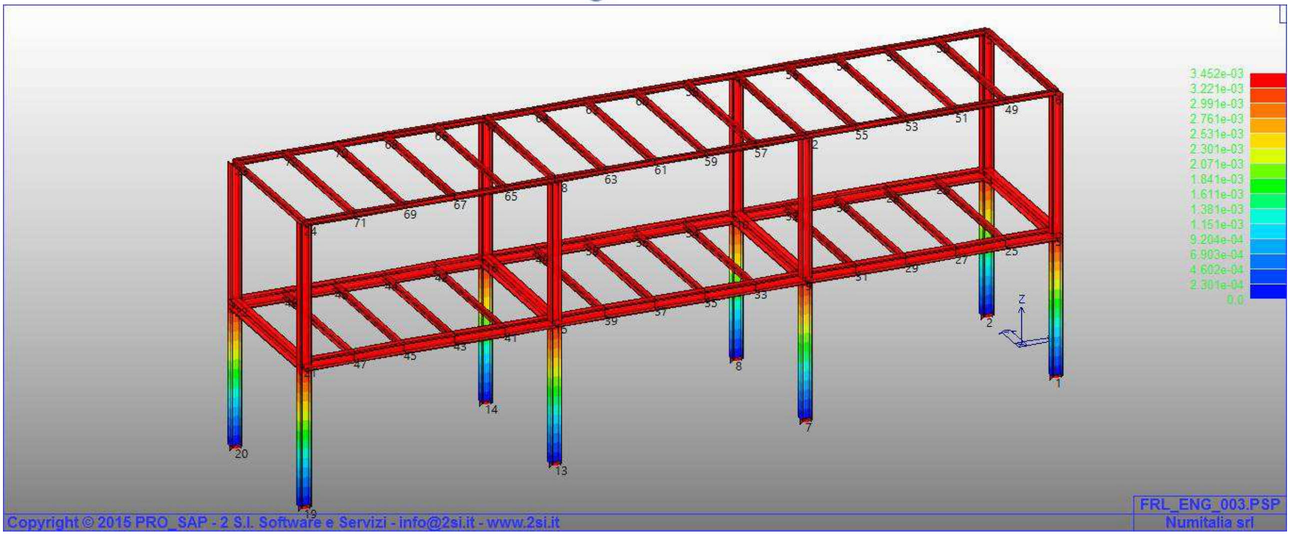


Figure 6: Strain due to p3

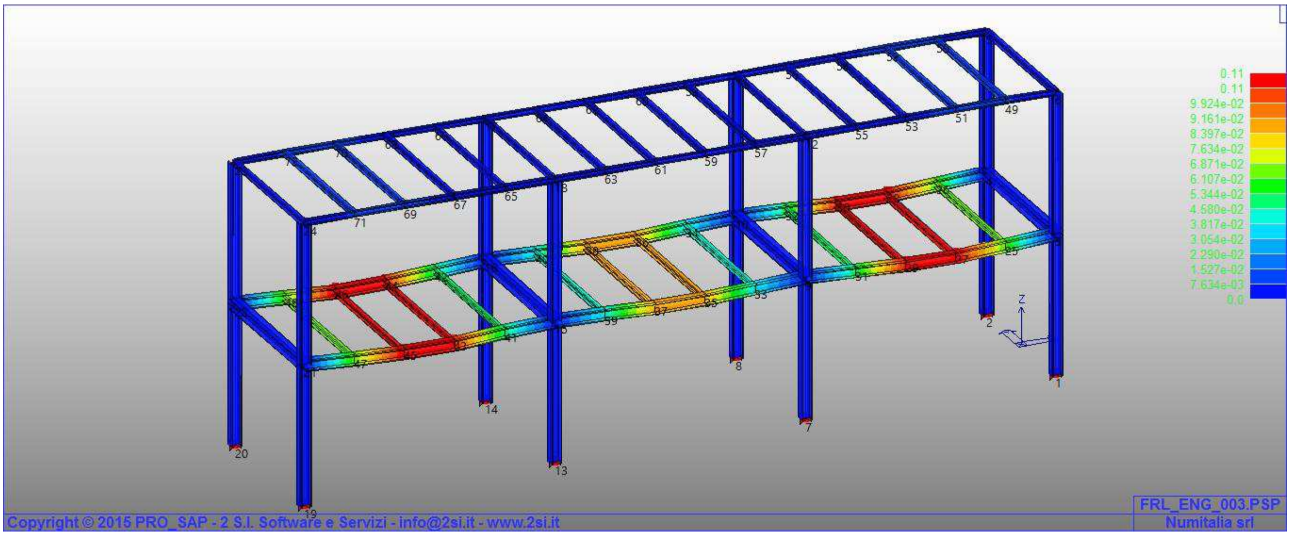


Figure 7: strain due to p4

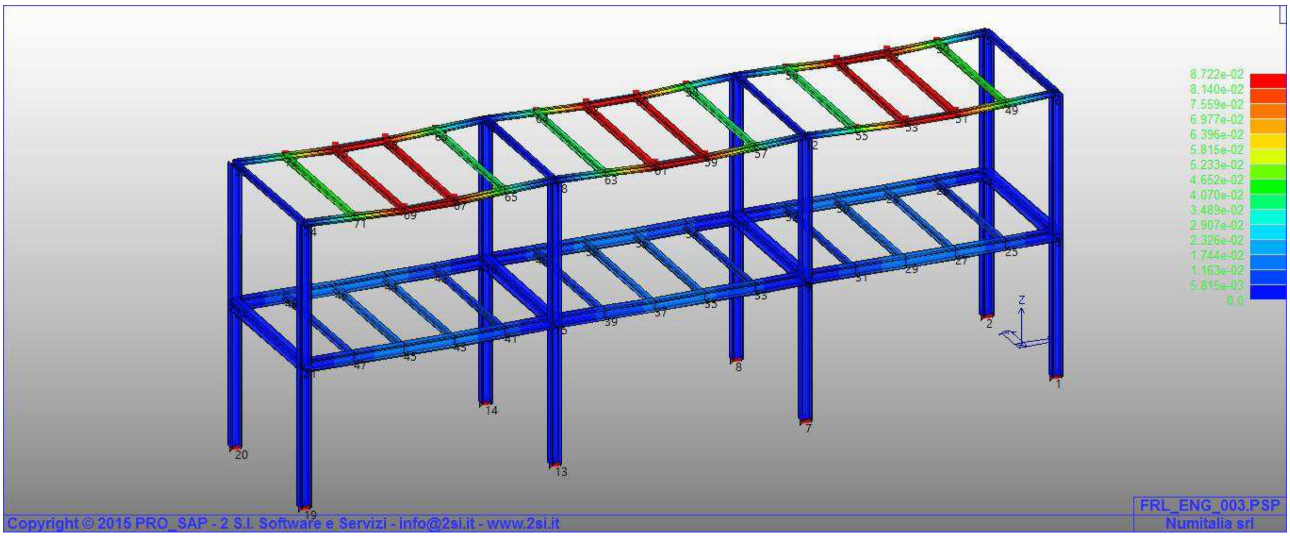


Figure 8: strain due to weight

All these pictures clearly show that strain is always around 1/10 cm.

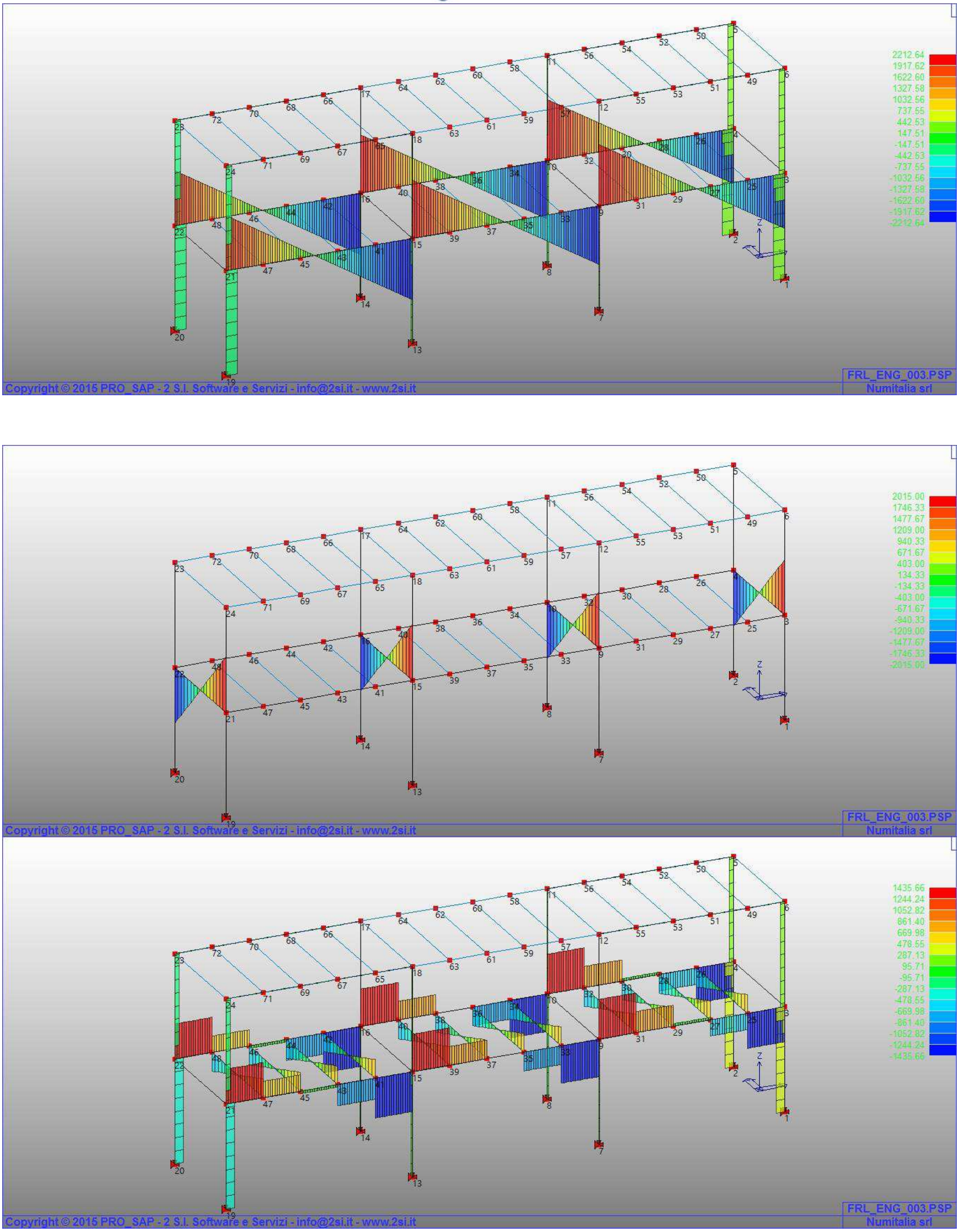
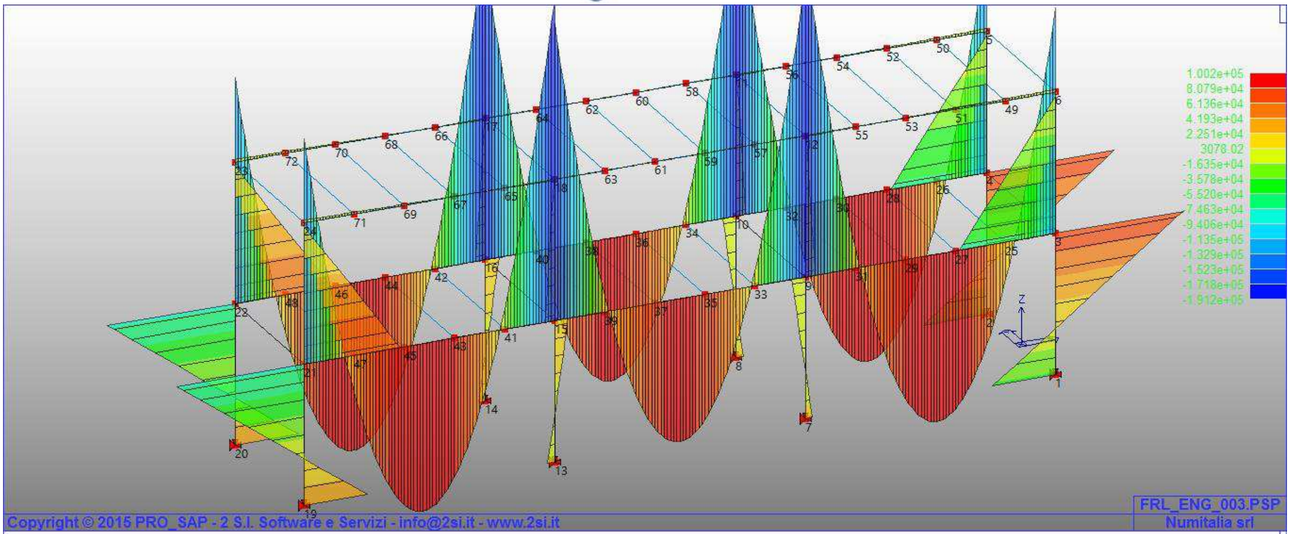


Figure 9: Shear due to p1, p2, p3 and p4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6.136e+04
4.193e+04
2.251e+04
3078.02
-1.635e+04
-3.578e+04
-5.520e+04
-7.463e+04
-9.406e+04
-1.135e+05
-1.329e+05
-1.523e+05
-1.718e+05
-1.912e+05
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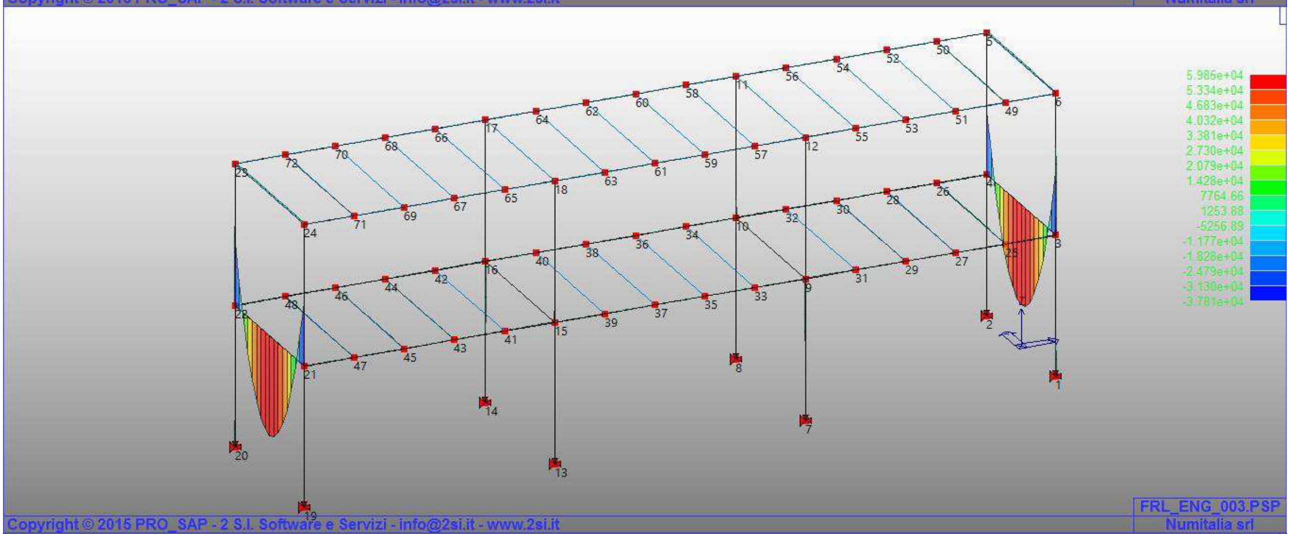
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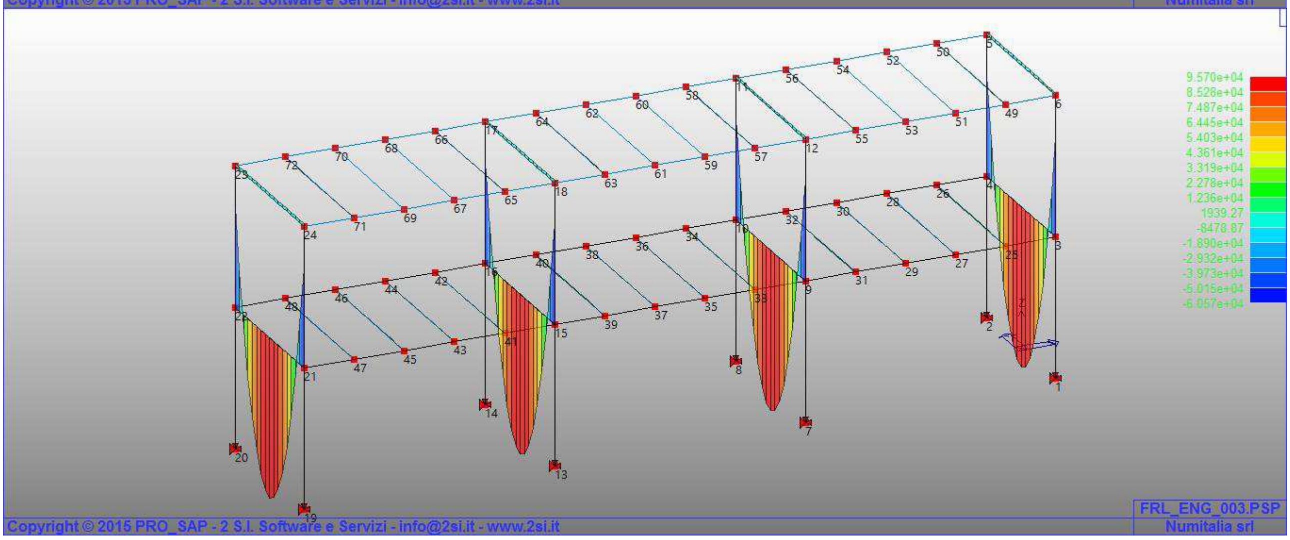
5.334e+04
4.683e+04
4.032e+04
3.381e+04
2.730e+04
2.079e+04
1.428e+04
7764.66
1253.88
-5256.89
-1.177e+04
-1.828e+04
-2.479e+04
-3.130e+04
-3.781e+04
FRL_ENG_003.PSP
Numitalia srl
Copyright © 2015 PRO_SAP - 2 S.I. Software e Servizi - info@2si.it - www.2si.it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1.236e+04
1939.27
-8478.87
-1.890e+04
-2.932e+04
-3.973e+04
-5.015e+04
-6.057e+04
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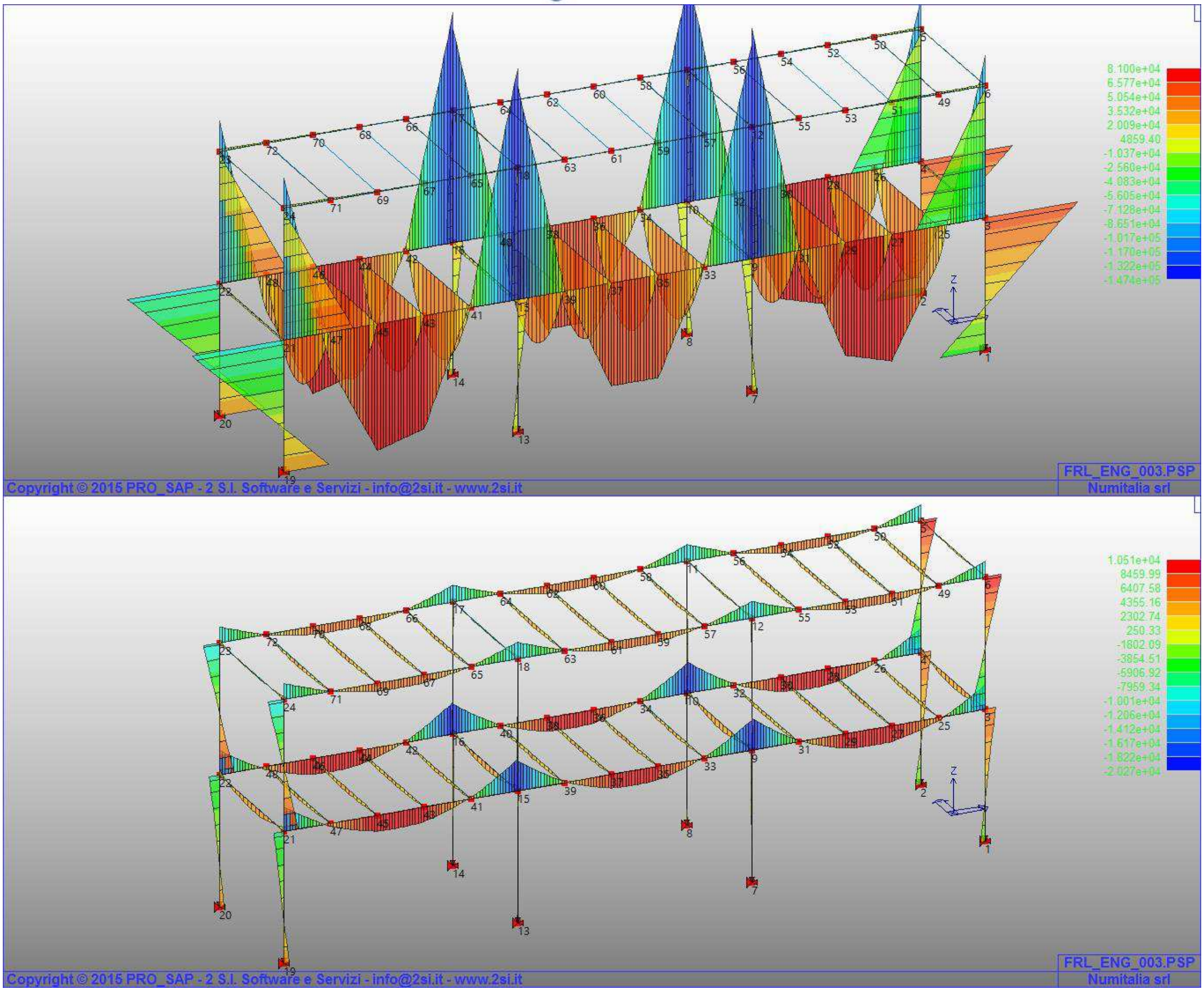
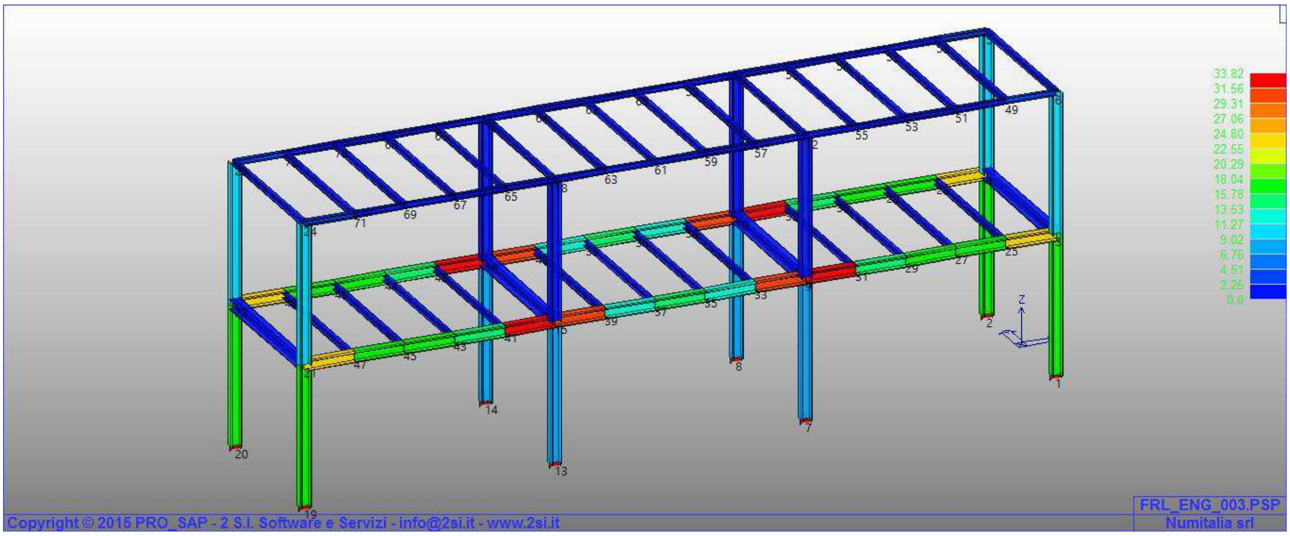
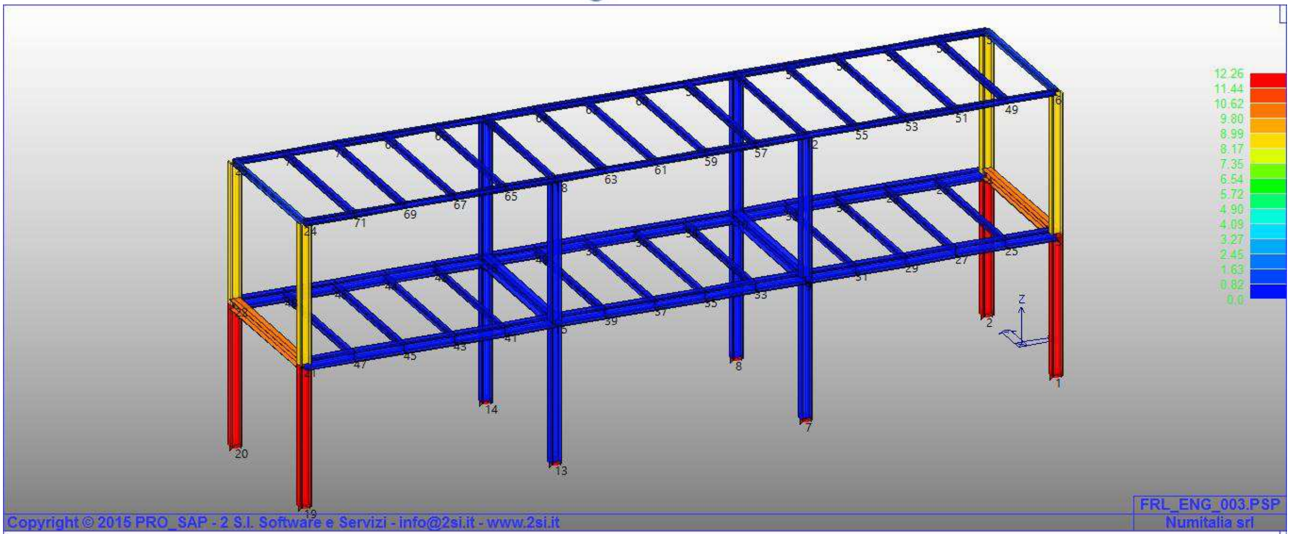


Figure 10 Bending Moment due to p1, p2, p3 and p4 and weight

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11.44
10.62
9.80
8.99
8.17
7.35
6.54
5.72
4.90
4.09
3.27
2.45
1.63
0.82
0.0
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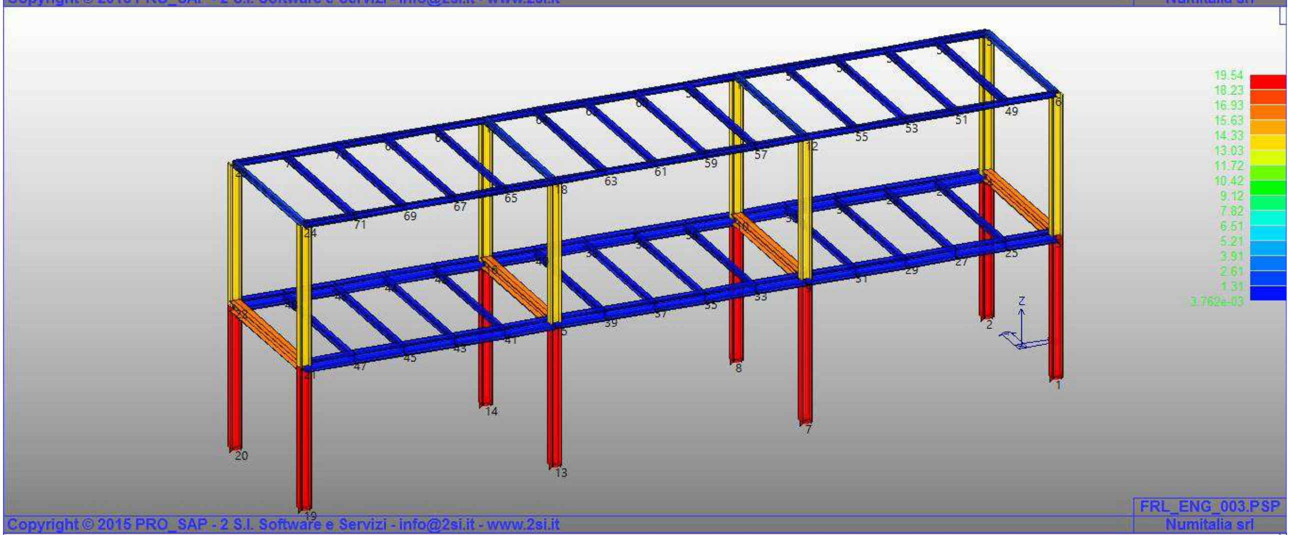
19.54
18.23
16.93
15.63
14.33
13.03
11.72
10.42
9.12
7.82
6.51
5.21
3.91
2.61
1.31
3.762e-03
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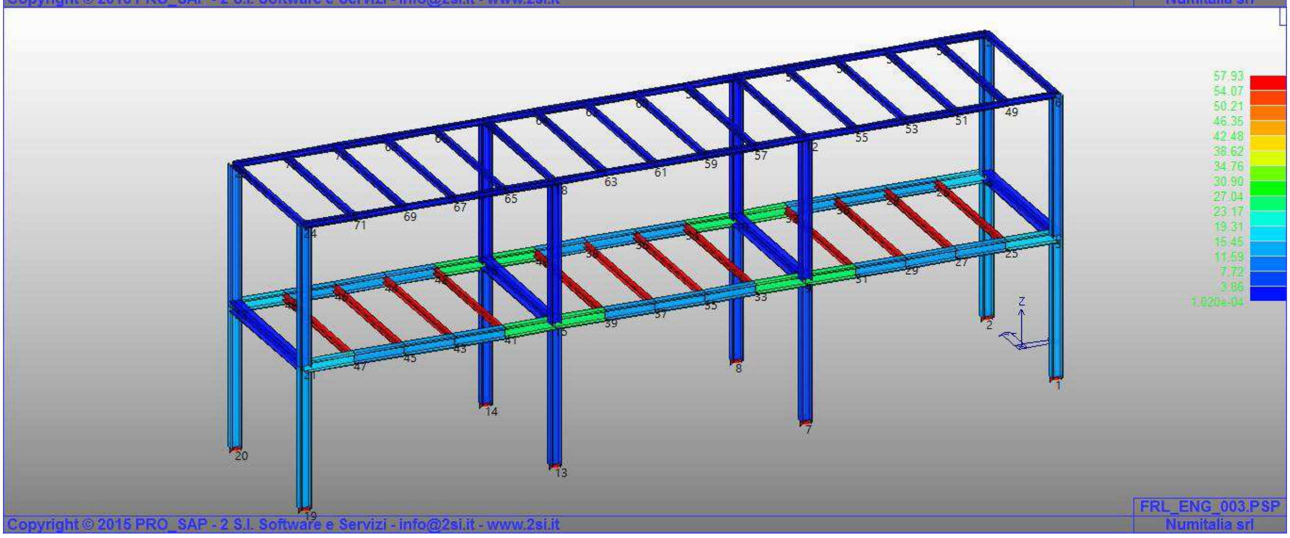
57.93
54.07
50.21
46.35
42.48
38.62
34.76
30.90
27.04
23.17
19.31
15.45
11.59
7.72
3.86
1.020e-04
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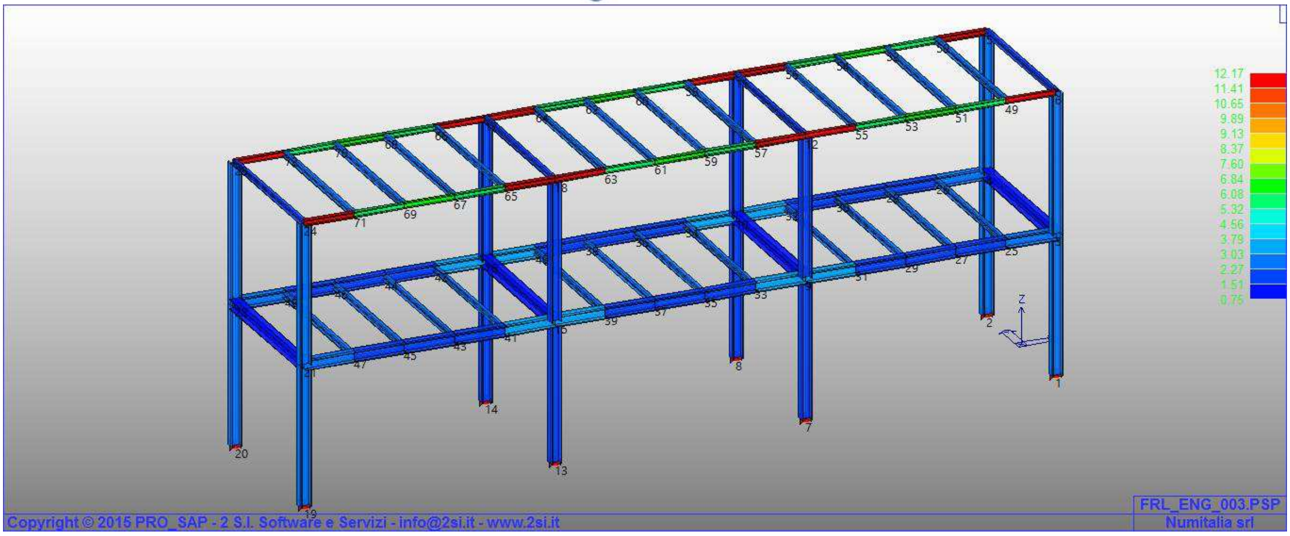


Figure 11 Normal stresses due to bending moment and normal force caused by p1, p2, p3, p4 and weight

Shear stresses are NEGLEGIBLE

We can conclude and observe that NONE of these plot [expecially those of normal stresses] reveals any possible state of failure.

Maximum normal stress is around 55MPa which is far less than yelding stress of S235 giving a safety margin of around 4-5.

It has to be considered that this safety margin is achieve while putting an increase factor of 1.5 on the loading case... So we can conclude that real safety margin should be in the range of 6.

Program SAP yelds even a plot of the verification of the structure

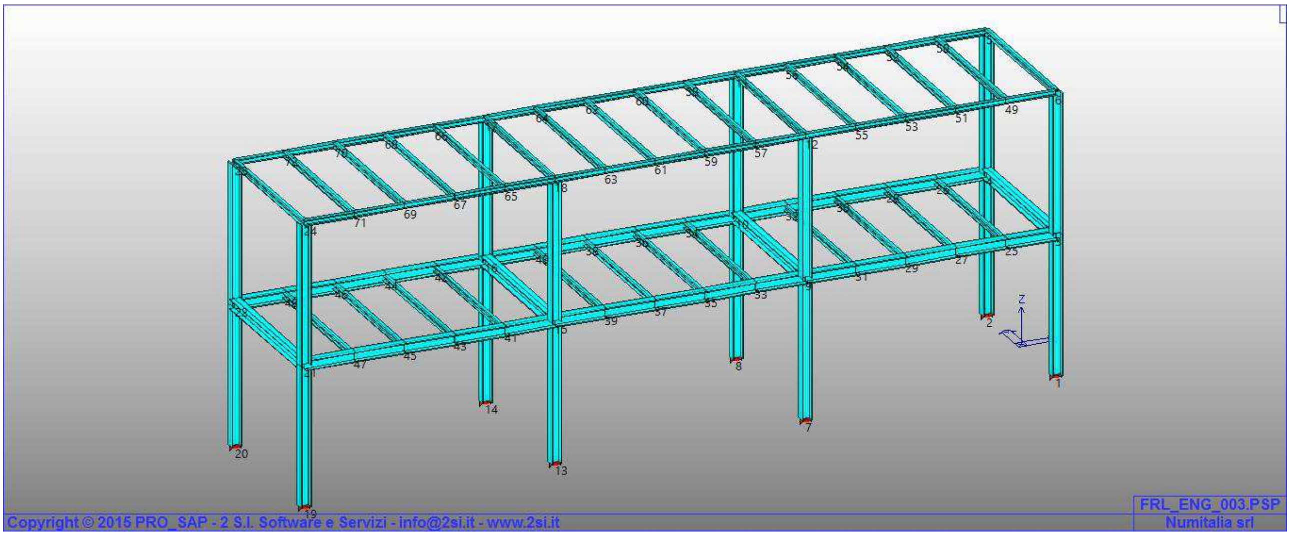


Figure 12: Status of the project

Cyan colouring means that **NONE of the beams is subjected to failure**:

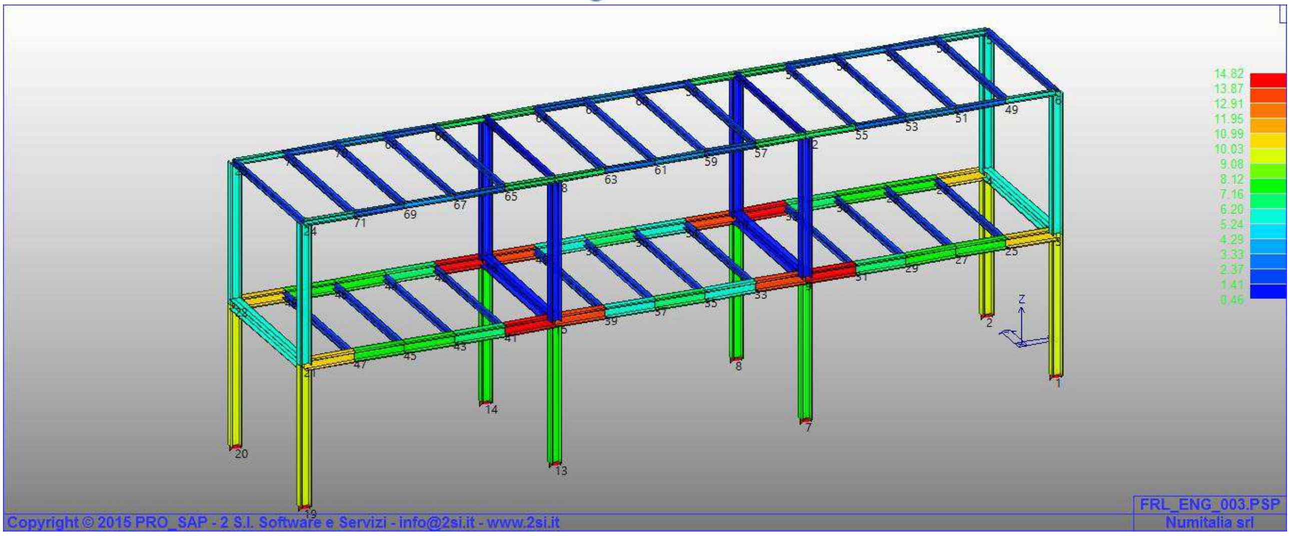
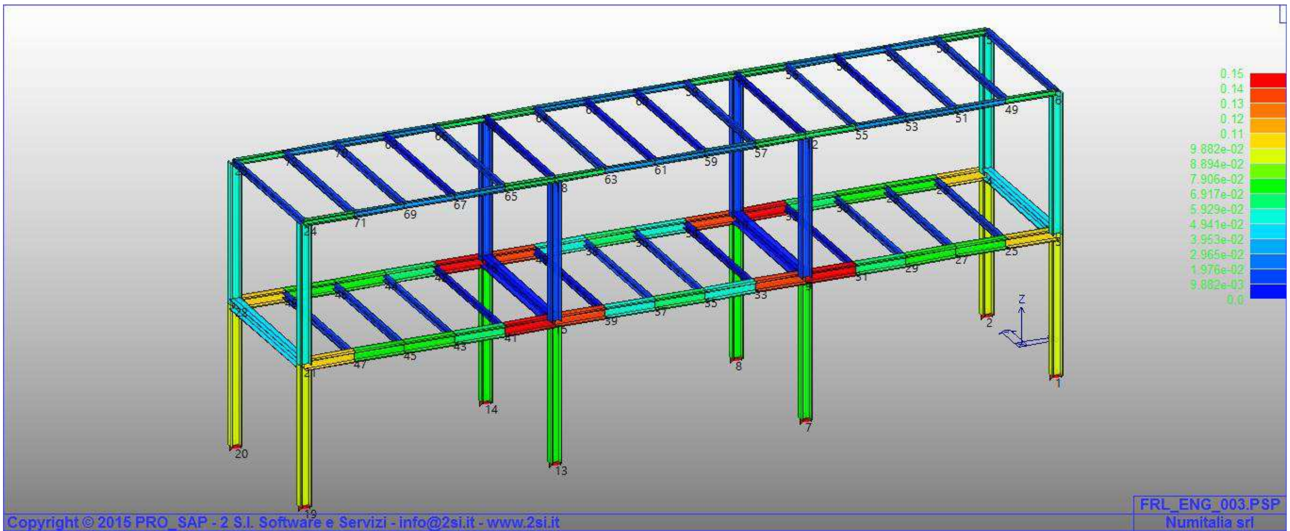
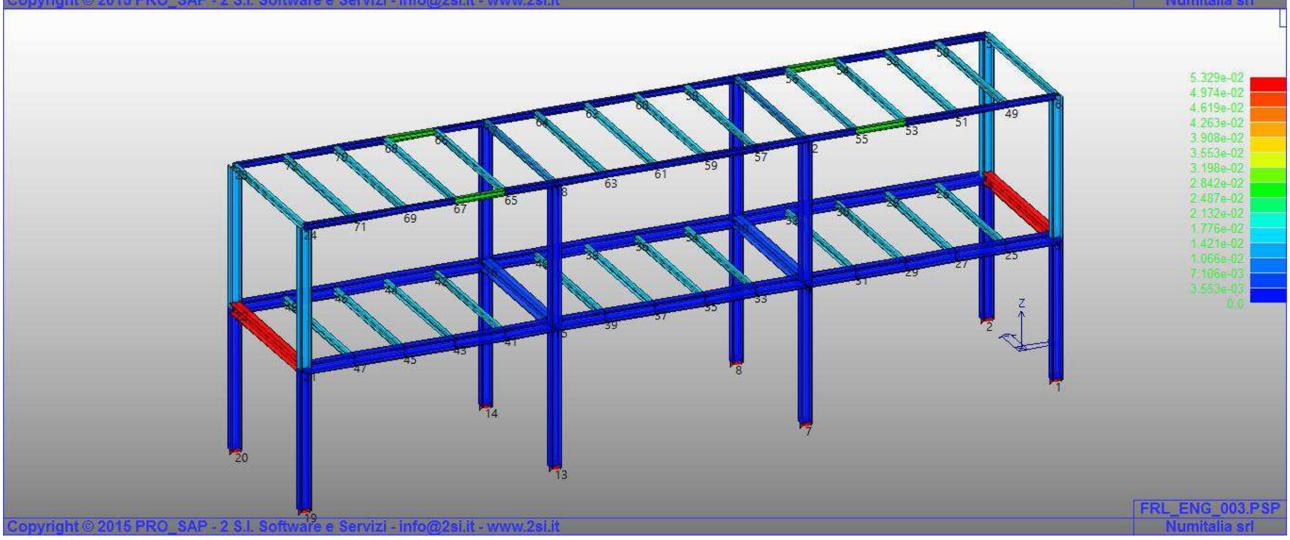


Figure 13: Material residual resistance

This plot above is indeed more precise. It evaluate the residual resistence of all of the beams. Red beams are used for their 15% of resistance and this is the max usage of the resistance in the whole framework.

So 85% of the material used to build this structure is indeed in excess going in favour of safety.





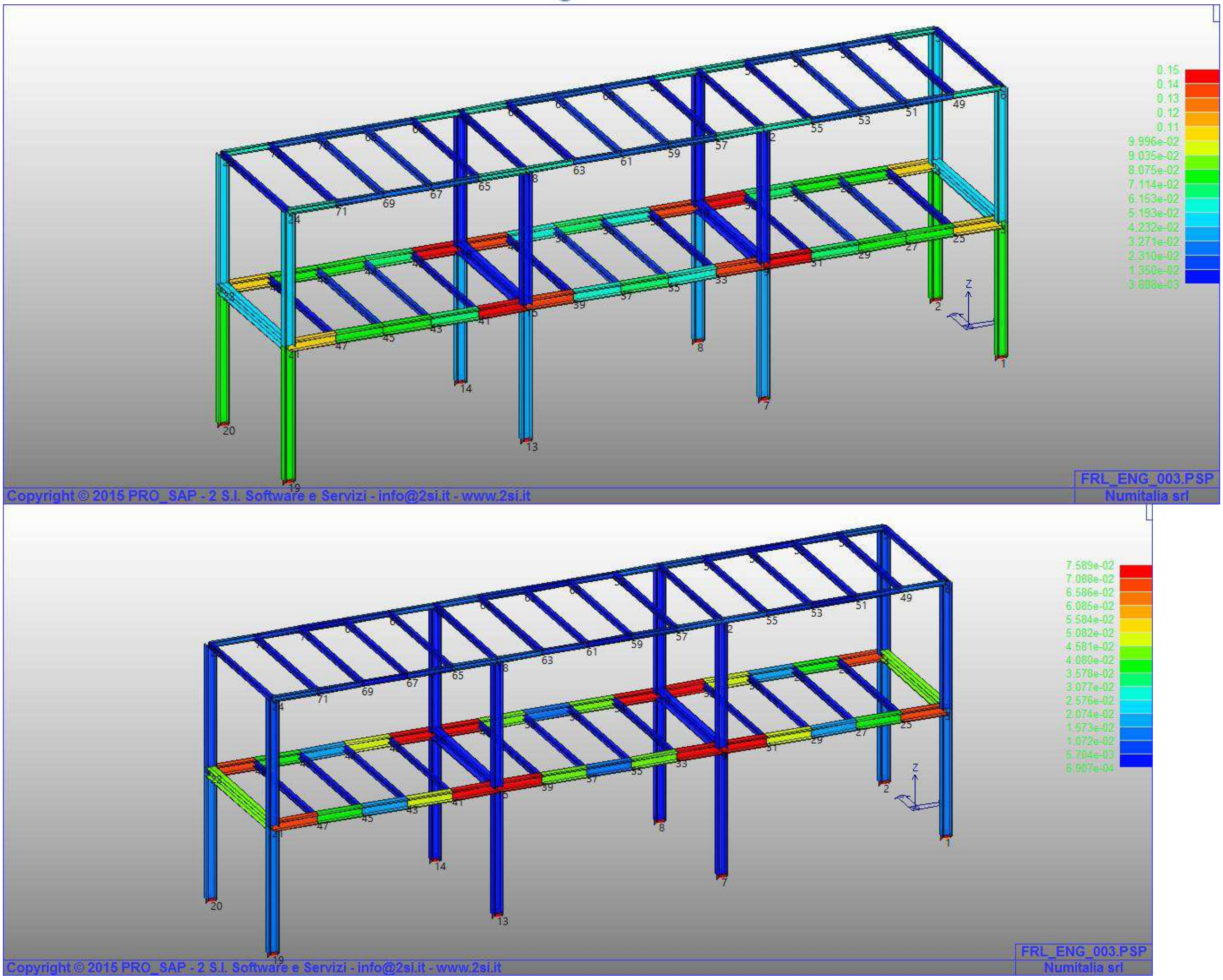


Figure 14: Failure mode due to shear, normal stress, bending torque

Above pictures show failure modes due to shear, bending, torque stresses. Checking out the colour plot it can be easily noticed that the order of magnitude of the maximum tension compared to the allowable yelding stress using von Mises criteria is always less than 1/10, but normally is less thant 1/100

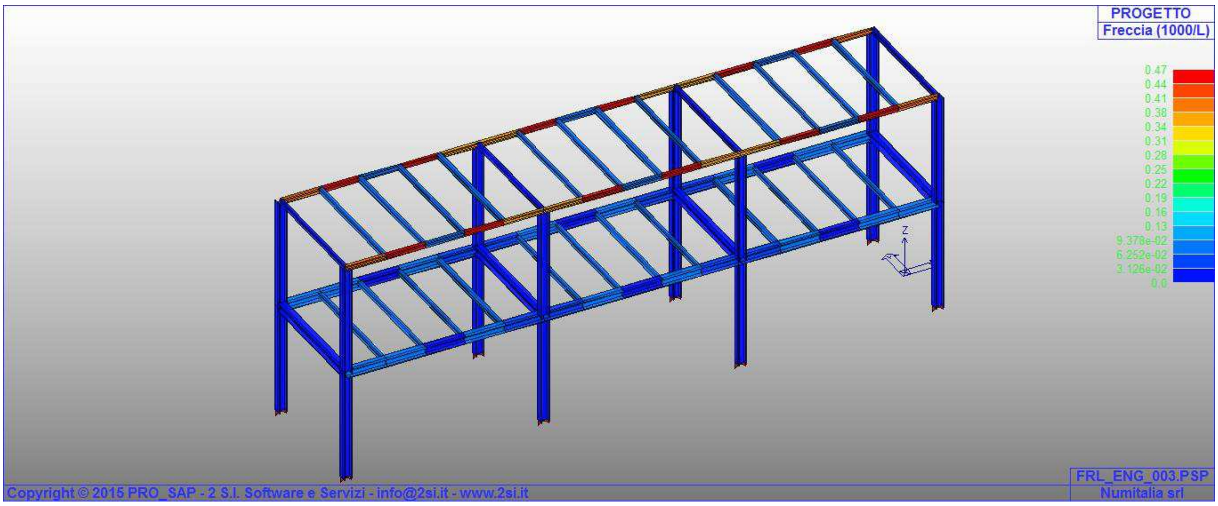


Figure 15 max strain

This last plot indeed reveals that the maximum achieved strain compared multiplied by 1000 and divided by a reference lenght is always less than .47, so negligible.

CONCLUSIONS

Accordingly to the computations performed, it can be reach the following conclusion.

The framework structure defined in this report, build within the avaible best construction technologies following design blueprints, respecting positioning of elements and constraints defined in the "general description of the project" is well dimensioned and capable of support external design loads.

Maximum strain is far less than the limit of 1/500 of the characteristic lenght.

Maximum stress is very far less than the yelding stress, resulting in a safety margin of 6.

Due to the location site, no seismic load has been considered accordingly to normatives

All these issue leads to conclusion that the structure is correctly sized and dimensioned.

Two more conclusions can be drawn:

- The persistence external loads insisting on the Structure and causing a level of stress so low, should suggest to modify the choice about columnar elements.

  It maight be noticed that HEB200 is largely oversized. This may leads to replace those beams with smaller ones such as HEB140 or less. It could be decided to use the same standard element for all the framework, which could be built out of HEB140.

  Constructor choice is anyhow appriciated because it goes in the direction of SAFETY.

- Second consideration has to be done on the Foundation.

  In order to get required stiffness for the support of the main column a dig of 600x600x600mm has been performed to pour concrete [RBK400] within is reinforcing steel web of 12mm in diameter.

  This solid block of reinforced concrete is then closed at ground level with a thick solid steel plate. The two element define a solid rigid base where main column can be welded.

  So, considering that in the worste case scenario the load on the basemen per each column is around 41kN, this yelds to a pressure of 41kN/[0.36m^2]=0.11MPa. *Since RBK400 gives a compression resistance of 400MPa, this means that foundations are LARGELY oversized with respect to the loads*.

the Surveyor

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Date September, the 25th 2016