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Easy tools for light steel framing design, architectural conception: state of the art

Arcelor Research Center, Liège Belgium, June 22nd, 2006

SteelHouse – Construction - System:

a high quality light steel solution for answering to the earthquake constraints

The company: Scope - History

- long established experience in constructions of internal building

- by the mid of 2003, SteelHouse enters in the field of residential constructions

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STEELHouse ADVANCED SOLUTIONS IN CONSTRUCTION

Steps Forward – The Network

- Head offices: Patras, Peloponnese
- Developing of know-how based on local needs-restrictions, common projects with university
- Creation of skilled workers through seminars
- Strategic alliances: material suppliers, contractors
- Establishing network of authorized contractors in the west side of Greece – Ionian Islands

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Steel House-Construction-System

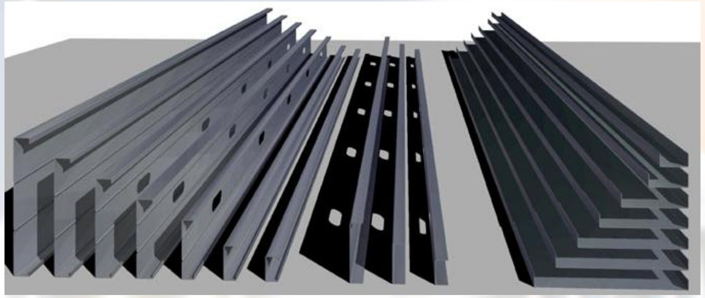
- Cold-formed lightweight steel profiles
- Oriented-Strand-Board (O.S.B.) for sheathing
- Exterior Insulation and Finish System E.I.F.S.
- Drywall system for interior finish

SCS
SteelHouse - Construction - System

Cold-formed lightweight steel profiles

Combination of C- and U-shape profiles

- Wall framing: C150 – thickness 1,5mm
- Floors: C250 – thickness 2mm
- Roofs: C100 – thickness 1mm-1,5mm
- Connections: self drilling screws, anchor bolts



Benefits

- Strength and Durability
- Minimum weight of construction-high loadbearing capacity-minimum transport cost
- Quick construction with precise dimensions

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Examples

Oriented-Strand-Board (O.S.B.) for sheathing

- Engineered wood structural panel
- Long strands of wood bonded with synthetic adhesive
- Three layers
- O.S.B./3 for loadbearing purposes in wet conditions

Benefits

- High mechanical strength
- Dimensionally stable
- Moisture resistant
- Smooth surface ready for E.I.F.S.

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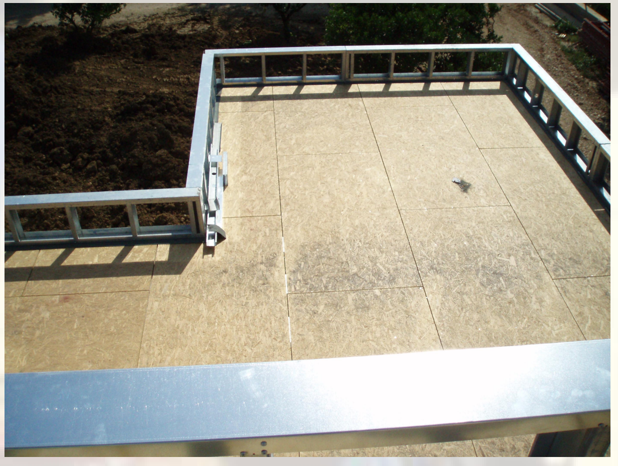
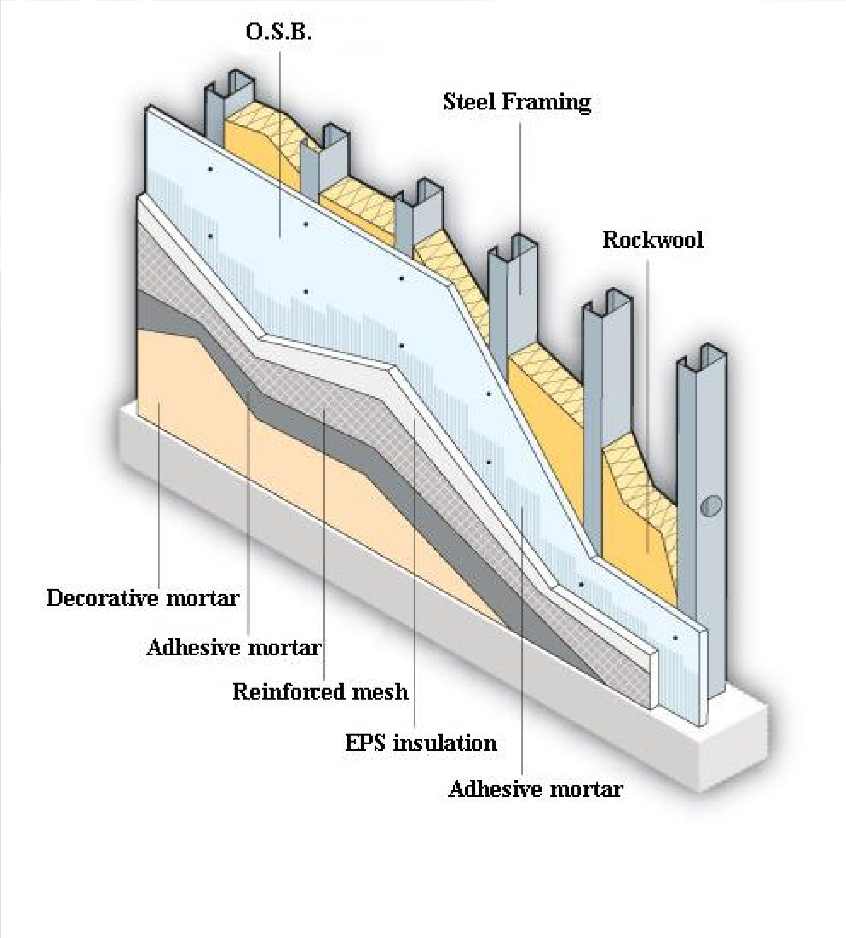
Examples



Exterior Insulation and Finish System E.I.F.S.

Consists of:

- Breathable membrane
- EPS boards
- Adhesive mortar (1st layer) with mesh
- Primer
- Decorative mortar



Benefits

- Energy Efficiency
- Design Flexibility
- Protection against water intrusion
- Long term durability

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Examples

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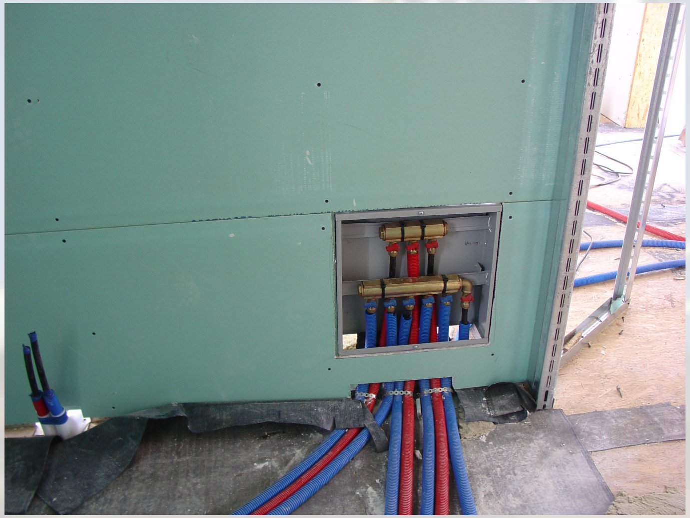
Drywall systems for interior decoration

- 2 layers of gypsum board 12,5mm each
- Rockwool for insulation

Benefits

- Freedom in architecture
- Fast construction - no “drying” periods
- Quality finish of surfaces

Examples



:: Technical presentation

Structural Materials

Continuous hot dip zinc coated carbon steel sheet of structural quality (EN 10147)

1. FeE 280G (fy=280N/mm2 – fu=360N/mm2)
2. FeE 320G (fy=320N/mm2 – fu=390N/mm2)
3. FeE 350G (fy=350N/mm2 – fu=420N/mm2)

$E = 210.000\ N/mm^2$, $G = 80769\ N/mm^2$, $v = 0.3$, $\rho = 7850\ kg/m^3$

Oriented Strand Board – OSB (EN 300)

OSB/1: General use for interior areas
OSB/2: Bearing elements in dry conditions
OSB/3: Bearing elements in both wet and dry conditions
OSB/4: Bearing elements under high loads in both wet and dry conditions

+ excellent strength/weight ratio
+ high stiffness
+ durability under every conditon
+ industrial product with standards and cerificates

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Structural Materials

OSB STRUCTURAL PROPERTY	Unit	Thickness	
		10-18mm	18-25mm
Bending strength – major axis	N/mm^2	20	18
Bending strength – minor axis	N/mm^2	10	9
Meter of Elasticity – major axis	N/mm^2	3000	2500
Meter of Elasticity – minor axis	N/mm^2	2000	1600
Meter of Shear – major axis	N/mm^2	200	200
Meter of Shear – minor axis	N/mm^2	1000	850

OSB MECHANICAL PROPERTY	Regulation	Demand
Tolerance in Nominal Dimensions	EN324	+/-3mm
Edge straightness tolerance	EN324	+/-1.5mm/m
Squerness tolerance	EN324	+/-2.0mm/m
Moisture Content (OSB/3 – OSB/4)	EN322	5 – 12%
Tolerance in board density	EN323	+/-10%

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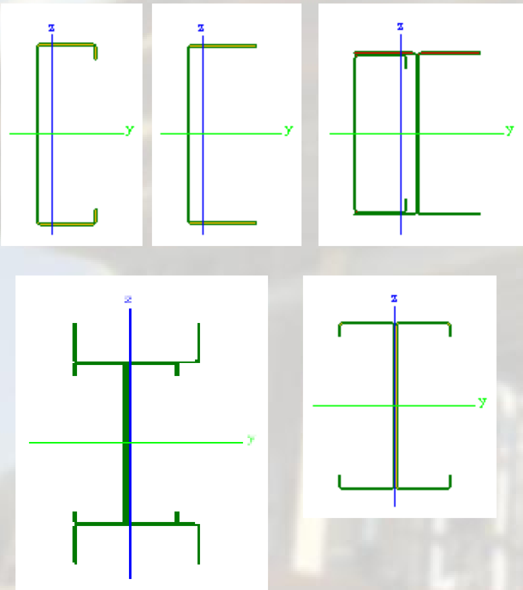
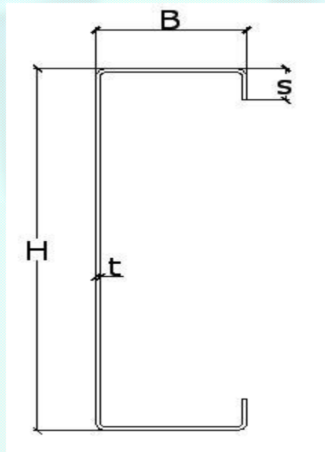
Steel Sections

Cold formed C and U light weight profiles (can be combined to form back to back or other configuratuons)



Basic C & U profiles	Dimensions				Drawing
	H	B	s	t	
C100x1.5	100	50	13	1,5	
C150x1.5	150	50	13	1,5	
C250x1.5	250	65	20	1,5	
C250x2.0	250	65	20	2,0	
U100x1.5	104	60	-	1,5	
U150x1.5	154	60	-	1,5	
U250x1.5	254	65	-	1,5	
U250x2.0	254	65	-	2,0	



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Load Cases

- **Dead and live loads – Greek loading code**

  Self weight of steel

  Sheathing weight (e.g. Gypsum board, OSB, tiles)

  Non bearing elements weight (e.g. interior walls that are not modeled, insulation)

  Q : 2KN/m^2 for floors and 5KN/m^2 for balconies

- **Wind and snow loads – Eurocode 1**

  High wind coastal areas – Vref,0 = 36m/sec for Greece

  e.g for a zone 3 site qref= 0.81KN/m^2

  Snow load of 0.25KN/m^2

- **Seismic loading – Greek antiseismic code**

  Lateral loads due to ground movement (earthquake) that induce an acceleration on the mass of the structure, thus a force

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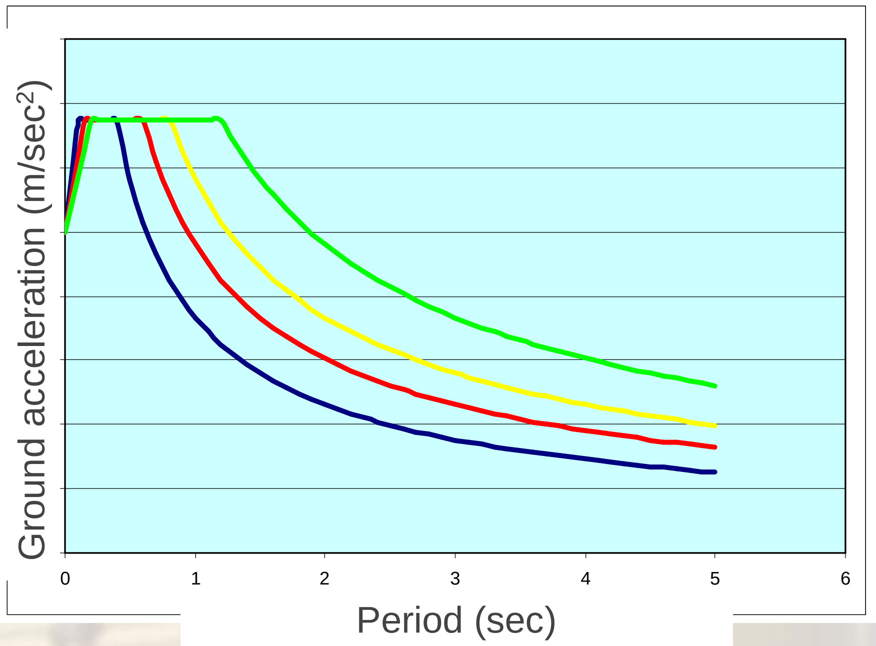
Load Cases

- **Seismic Loading – Greek antiseismic code**

  Modal dynamic analysis using a responce spectum



- Site location (3 levels of seismic risk)
- Type of soil (e.g clay) and type of foundation (e.g. single footings)
- Use of structure (e.g residence)
- Type of structural system (e.g. steel frames)

We must define as well :

- a q factor that represents the ability of the structure to yield

  (q=1 perfectly elastic structure)

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Load Cases

- **Seismic Loading – Greek antiseismic code**

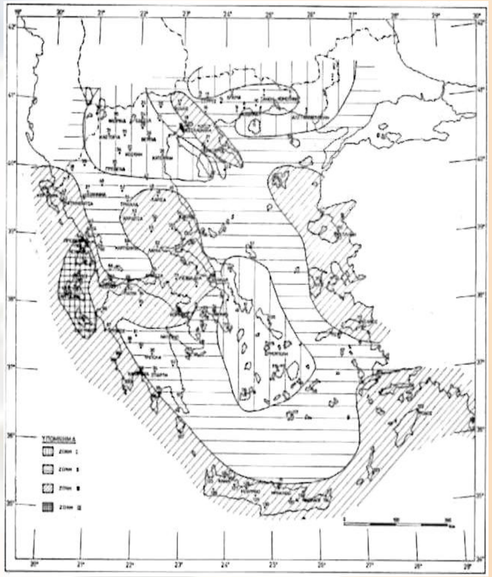
Amplification coefficient for the responce in upper floors : b_0=2.5

Mass of structure is calculated from : Dead Loads + 30% Live Loads

Combination of the seismic loading in every principal direction X, Y, Z

$$E = E_x + 0.3E_y + 0.3E_z$$
$$E = 0.3E_x + E_y + 0.3E_z$$
$$E = 0.3E_x + 0.3E_y + E_z$$

Combination of the seismic loading with dead and live loads



Worst case seismic acceleration scenario

- Highest sesmic risk area ⇒ Ground acceleration of 0.36g (All other factors equal to 1)
- Perfectly elastic sturcture ⇒ q = 1

⇒ **8.83 m/sec²**

A mass of 10.000kg at that acceleration would produce a force of about 90KN

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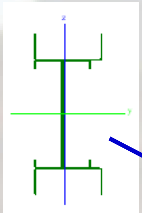
Modeling the Structural System (ESA PT software)

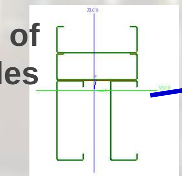


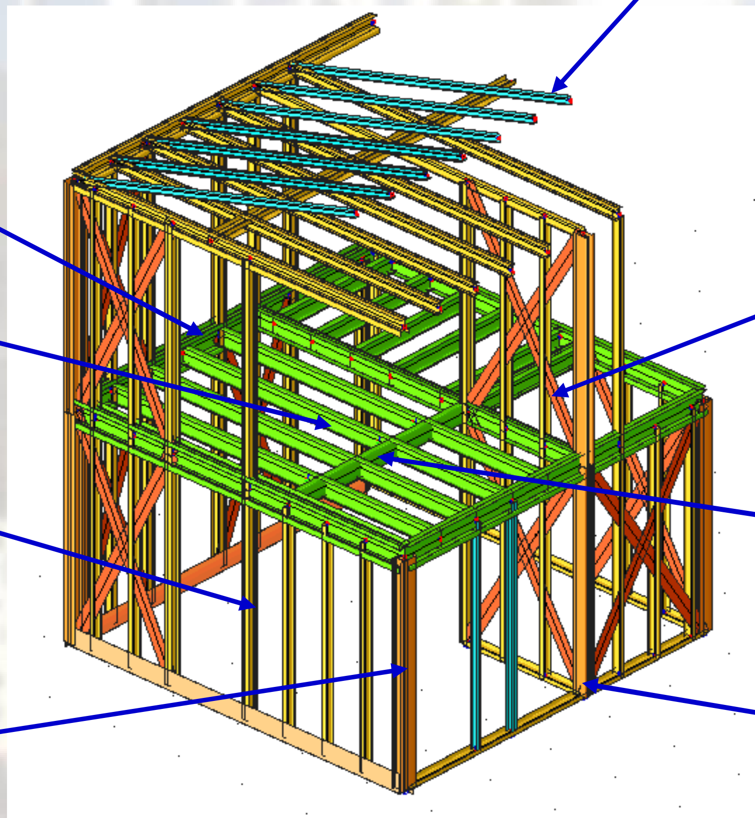
Combination of C & U profiles for the joist to bearing wall configuration

C or 2C profiles for the roof joists

C or 2C profile studs for the wall framing

Corner configuration of multiple C or U profiles





C profiles for roof rafters

Diagonal straps for lateral loads

Blocking

Achorage at corners

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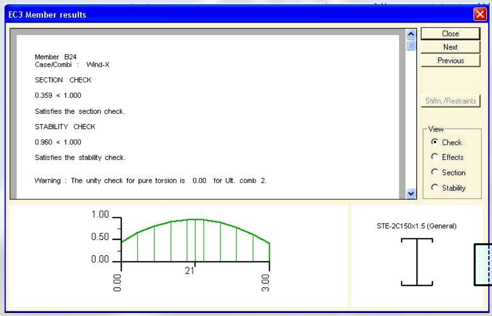
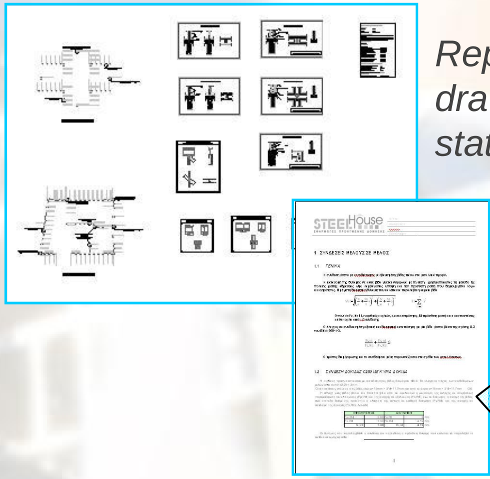
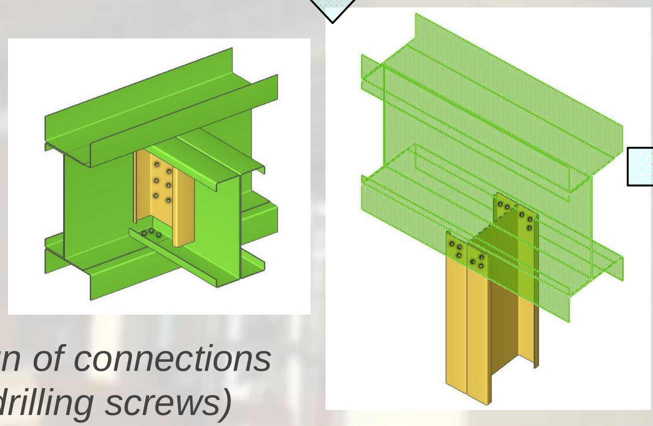
Design



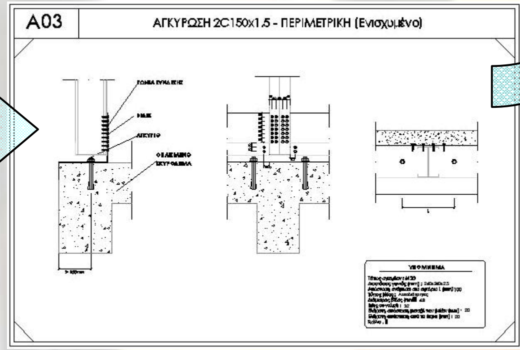
Section and member check according to EC3



Reports and drawings to state inspectors



Design of connections (self drilling screws) according to EC3



Design of foundations and anchorage according to Greek Concrete code

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Room for improvement...

- **OSB Behaviour**

The contribution of OSB panels is major in the stability and strength of the whole structure since it acts as a diaphragm in roofs and walls that can withstand lateral loads.

Nonetheless, OSB can not be easily included in the analysis.

- The shear load capacity of the panels depends not only on the board itself but on the assembly (e.g number and distance of screws) as well as the general wall geometry (openings, dimensions)

-Eurocodes do not provide any standards or norms for the behaviour and strength of that kind of shear walls

WE NEED :

- Further testing on OSB behaviour under various configurations and a supporting European regulation

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Room for improvement...

- **Connections**

Connections on heavyweight steel have been extensively tested and theoretical models have been developed. On lightweight steel connection data and models are very limited.

Models applied for heavyweight steel are inadequate and possibly unsafe if used in lightweight construction. A structure does not only fail due to member failure but due to connection failure as well.

WE NEED :

- Models that can accurately predict the connection – nodal behaviour
- Update of european norms

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Room for improvement...

- **Software**

A typical model of a single storey residence would approach 1000 members and a few hundred of nodes. This numbers are huge compared to a column and beam approach of a model.

Without the aid of appropriate software in the implementation of the model, in its design and in its drawing plans, the entire procedure would be uneconomical both in terms of money and time. For the time being there is not a software package that can cover every aspect of design and drawing.

WE NEED :

- Software to facilitate the connection design and anchorage of lightweight construction
- Better software cooperation, precise model transfer from design to drawing software and the opposite

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Room for improvement...

- **Lightweight constuction standards**

Lightweight constuction is something new to Greece. Goverment inspectors and services do not have a regulatory frame to use and comply with. Problems we face are :

- Crossection checks (class 4)
- Behaviour of the whole system under intence dynamic loading
- Earthquake loading to be used
- Connection design approach
- Insulation and fireproofing of metal and wood
- Quality control and certifications
- Design and analysis software

WE NEED :

A complete new regulation applicable to every European Union member that can be referenced for the design and the standards of lightweight construction.

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Why do we choose a sytem like that...
...in a country like Greece

- Light weight means less mass and thus less seismic force.
- The system eventually comprises not of single studs and joists but of shear and diaphragmatic elements that act together to withstand seismic lateral loads much more efficiently.
- Better quality control through prefabrication
- Detailed drawing plans permit percise and easy to check assembly of every element
- All the materials combined in the SCS are industrial and certified providing a superior quality of the entire structure
- Efficient and quick repairs of possible minor damages in a structure due to frequent seismic events

A safe, highly aesthetic, cost efficient, time efficient, of superior quality and durability housing solution

Applications

Single family houses
Renovation – add floors to existing buildings
Hotel construction – Bungalows
Warehouses
Small industrial buildings
Offices

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Key success factors → real estate opportunities

- Earthquake safety
- High level of thermal and acoustic insulation
- Minimize construction time
- Architecture
- Lower cost compared to concrete construction

- Environmental friendly