RFCS research project

Renovation Of Buildings Using Steel Technologies

ROBUST **Contract n° RFSR-CT-2007-00043**

Work Package n°5

Steel-intensive technologies for building extensions and conversions

CONTRIBUTIONS FOR THE FINAL REPORT

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WP5 – FINAL REPORT CONTRIBUTIONS

Steel intensive technologies for building extensions & conversions

TABLE OF CONTENTS

The need to create new spaces remains for the residential as for the economic and social activities. But the lack of available grounds and difficulties of transportation due to the urban spreading do not allow to answer the market demand. At the same time, it is important to get ready for the energy challenges of the future.
In this way, the refurbishing sector is a way in which the steel can bring successful answers.

1 Economical justification towards a software tool

The tool to develop in WP5 shall be targeted at building owners and real estate (light level), architects and designers (more complex level). The aim of this tool is to be useful in the early stages of a project to compare the costs of steel solutions with other way of building.
After a wide collect of data about market value or technical aspects, the second step had consisted to develop calculation method.

By observing the main market shares in the sector of the construction in Europe, the works of rehabilitation are about estimated on average at 50 % of the activity, any merged materials. Focusing the office sector, refurbishment and second hand are representing 60 % of the global market across Europe.

The economic motivation for any rehabilitation project is mainly to create an extra value and to increase the life of the existing building. The reduction of heating costs or the upgrade of performance regarding a new regulation shall more and more often be another reason to propose this kind of evolution for a building.
But in any case, the cost benefit 'balance' must be improved by new living space that can pay for the major part of the renovation work.

1.1 Economical aspects

Based on a global survey of European markets, there is often a lack of office/apartment space in city centres. The vertical extension concept could solve this basic need and in the same time take into account the improvement of energy-efficiency of the existing building.

Main criteria in favour of such approaches are as follows:

- An appreciation of the capital and a new commercial impulse;
- New attractive spaces are created in the same ground or within the existing infrastructure;
- An upgrade of global performance is proposed, especially a better thermal insulation;
- New parts of works offer also an improvement of aesthetics and possibly technical functionalities;

But from an economic point of view, the means of recover expenses - a part at least- due to the renovation needs lives the essential issue.

The model of 'European average' multi-storey building obtained in the WP3 studies was used to reach this goal in a virtual study.

1.2 Economical study for justification

To lead our economical study for a vertical extension project, the research has focused on a wide collect of data about market value or building items.
First, a short survey of European office market concerning economical elements provided typical values: rental value, prime rents, vacancy, etc. Information was essentially collected from reports made by main real estate companies of this sector.

Thus, market values from the most main cities in different countries were selected: land cost; purchase/rental value (€/m²). Rental prices in city centre (see table 1.1 - 2009 values) are beginning less than 200 €/m²/year and can reach 650 or even 1000 €/m²/year in central business districts.

RENTAL PRICES (€ / m² /year)		2008	2009	Trend
	Q3 - 2009			%
LONDON	**Central London**			- 8.50
	West End		555.44	
	City		1 033.37	
BRUSSELS	**CBD**	265.00	**265.00**	
BERLIN	**Prime Rent**	270.00	**240.00**	
	Potzdamer / Liepziger		220.20	
	AAA city East		216.00	
	AAA city west		171.60	
NORDIC	**Helsinki**	**350**	**340.00**	
	Stockholm		366.00	
	Oslo		336.00	
	Copenhagen		235.00	
PARIS	CBD		645.00	
	total of Paris		440.00	
	La Défense		480.00	
	Total Region		304.00	
	Immostat and CBRE Marketview - 2009			

Table 1.1: Rental prices in main cities

However, according to those different sources, the global demand is in fold from 500000 m² (2008) to 200000 m² (2009).

Set in France and introducing main building costs, the final stage of our study focused on a comparison of budget based on our average existing building and its vertical extension versus a new 6-storey building. The objective was a return on investment calculation.

For the construction stage, costs are concerning common parts of work, according to various ways of building:

- Additional main frame,
- New slabs including connections with existing upper level,
- New facades,
- Improvement of existing facades (thermal performances, aesthetics)
- Creation of new roof (slope or flat)
- Balconies, terraces, bow-windows

Conditions during demolition stage were also been taken into account.
Finally, the life cycle cost was focusing on energy consumption, based on current ratio.

Comparison takes into account the following buildings:

- 'reference': existing building without any improvement project,
- 'New Building' is a new one, made of concrete with thermal insulation,
- 'Steel' is a steel vertical extension and a new energy-efficient envelop on existing facades (see in chapter 2.1).

RETURN ON INVESTMENT Comparative study	Annual energy consumption (kWh/m²/y)	annual cost of energy (€)	Rental Income (€/y)	Annual balance €
Reference : 1345 m²	- 306 000.00	-10 710.00 €	538 560.00 €	**527 850.00 €**
V2 NEW Building	- 91 800.00	-3 213.00 €	807 840.00 €	**804 627.00 €**
V2 steel: 1345+672 m²	- 220 320.00	-7 711.20 €	807 840.00 €	**800 128.80 €**

SITUATION 1 Average values	Operating costs	Balance including Rental income vs Energy expenditure 2	3	5	Results after X years 10
Reference	0	1 055 700.00 €	1 583 550.00 €	2 639 250.00 €	5 278 500.00 €
V2 model: NEW BUILDING	3 182 400.00 €	- 1 582 142.40 €	- 782 013.60 €	818 244.00 €	4 818 888.00 €
V2 model: STEEL	1 442 440.00 €	157 817.60 €	957 946.40 €	2 558 204.00 €	6 558 848.00 €

SITUATION 2 disadvantageous comparison	Operating costs (demolition, improvement)	Balance including Rental income vs Energy expenditure 2	3	5	Results after X years 10
Reference (4-storey concrete)	0 No works	1 055 700.00 €	1 583 550.00 €	2 639 250.00 €	5 278 500.00 €
NEW BUILDING + Demolition	2 080 800.00 € lowest prices	-471 546.00 €	333 081.00 €	1 942 335.00 €	5 965 470.00 €
STEEL extension + thermal	1 723 880.00 € highest prices	-123 622.40 €	676 506.40 €	2 276 764.00 €	6 277 408.00 €

Table 1.2: Synthesis of RoI study

At the end, even with a disadvantageous way of comparison, the steel extension is rapidly interesting: an important data during the initial design process.

2 Sustainability approaches

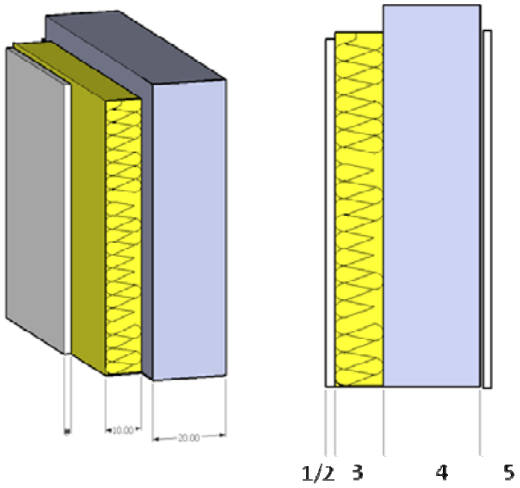
The sustainable approach is based on the same way of thinking than the economical.
The criteria have to take into account information from the product to the building.
In this chapter, a part is especially devoted to the increasing of U value, directly linked with the previous economical assessment.

2.1 Assessment of U-value on a vertical extension using steel

This part of the study was focused on the thermal characteristics (U-value) of our 'european average" building in order to establish links between energy improvement and economical justifications.

Main characteristics are:

- 4-storey building, with flat roof, but without basement, wooden windows with single-glazing (4mm)
- Standard gas boiler, collective hot water production, single flow ventilation.



Wall composition / existing concrete building

	Composition	Thickness (cm)	Lambda (W/m.K)
1	Cement coating	3	1.4
2	Vapour barrier / waterproofness	0.1	0.23
3	insulation board	10	0.039
4	Reinforced concrete 2300 , reinforcement 2%	20	2.3
5	Plasterboard	1.3	0.35

Fig. 2.1: wall composition of existing building

The purpose is to preserve land by creation of new living spaces and to improve the energy efficiency of building.

In this way, we considered a 2-storey extension with a steel frame and the implementation of good practices, as: individual condensation gas boiler, mechanical double flow ventilation, double glazing windows (4/12/4 and Argon).
Typical products are used to realize the new envelop: gypsum boards, mineral wool, air gap and tile cladding. The total thickness is 33 cm.

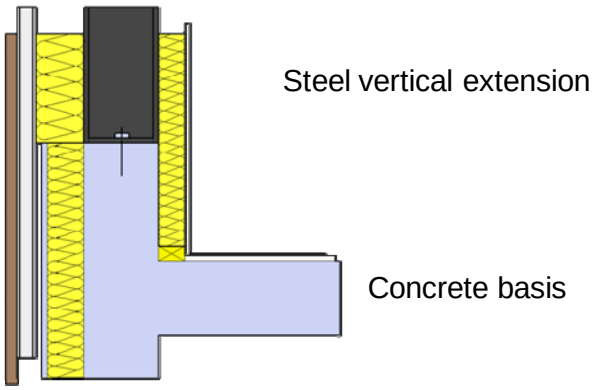
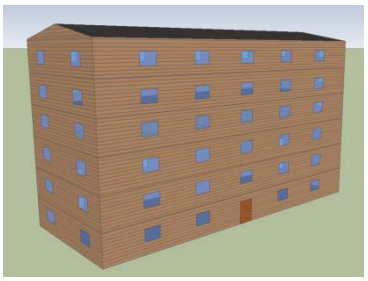


Fig. 2.2: proposed wall composition for refurbishing

The gross floor area is increasing: **+ 720 m²** (total: 2 160.0 m²) representing + 50 %.



	(u)	Existing	Steel extension	Steel extension and new windows
U bat	W/m².K	0.624	0.575	0.578
U bat ref	W/m².K	0.714	0.714	0.744
Gain	%	12.8	19.4	22.3

Table. 2.3 Summary of thermal gain between old and new building

The previous table shows the enhancement of U-value. The gain compared to U-value of reference is 12 % for existing model to 20% with both new floors.

2.2 BREEAM and HQE comparison

This comparison was lead to enlighten on the different strategies of BREEAM and HQE that could be established and the choice on a project specific target. For an "extension" development strategy, the aim was to show the possibility to achieve a coherent rating for the extension through different assessment methods (The rating doesn't include the whole development).

The two assessment methods considered where the BREEAM assessment with a BREEAM Bespoke undertaken at Design and Procurement (D&P) stage of a vertical extension case study in accordance with the BRE methodology (Building Research Establishment Environmental Assessment Method) and a HQE (High Quality Environmental standard) which is a standard for green building in France, both based on the principles of sustainable development.

Those assessments are series of environmental assessment methods and are voluntary schemes that aim to quantify and reduce the environmental burdens of buildings by rewarding those designs that take positive steps to minimize their environmental impacts. Despite the fact that one system is English and the other French, they both deal with the harmonious relationship between buildings and their immediate environment with similar key themes.

On this basis, in the case of a real "vertical extension project", a formal assessment would be out of any BREEAM standards and undertaken with the Bespoke checklist defined by BRE based on an accurate brief of the project at the design stage. In order to carry out this exercise, a simulation of a bespoke scheme has been set up listing all the potential credits applicable to specifically assess this kind of project

The study consisted in using the checklist HQE or creating a checklist as BRE would have done (The Bespoke scheme "vertical extension" set up is close to the multi residential scheme) and determine which credits are easily achievable and which credits are hard to take in place due to the configuration of the project or not even applicable.

Four kind of credits has been used:

1. Credits which are recommended for this kind of development as they are achievable to all projects irrespective of size or location.
2. Credits which are site specific and cannot be assumed on all projects, however they can be pursued/achieved where appropriate

3. Credits which are the most difficult to achieve in terms of procedure, design or may exceed cost targets, they require a particular design enhancement which could however be necessary to achieve the targeted rating.

4. Credits could not be applicable in the case of a "vertical extension"

For instance, the table below shows as a summary the allocation of all credits across all 10 BREEAM sections:

BREEAM SCORING MATRIX	BREEAM ENVIRONMENTAL WEIGHTING	Recommended credits A	Site specific credits B	Enhanced design credits C	Non applicable D	TOTAL CREDITS
MANAGEMENT	12%	12	1	7	1	20
HEALTH & WELLBEING	15%	13	0	2	1	16
ENERGY	19%	11	0	13	0	24
TRANSPORT	8%	1	5	0	6	7
WATER	6%	5	0	2	1	8
MATERIALS	13%	13	1	4	1	18
WASTE	8%	4	0	2	0	6
LAND USE & ECOLOGY	10%	5	9	2	5	12
POLLUTION	10%	3	6	4	6	13
INNOVATION		1	0	8	0	9
TOTAL CREDITS		68	22	44	21	A+C+D 133

Table. 2.4 Summary of Breeam assessment

In this case, where only the “vertical extension” in considered, the assessment shows that the certification process is impacted by the nature of the project as a significant amount of credits are “site specific” in which, a large part of them are directly non applicable. The used scheme will therefore, or integrates those “non applicable credits”, or deletes them from the scheme. In both options, this would positively impact the assessment allowing a good rating. A couple of credits are “site specific” but can still be rate like the impact on the biodiversity or noise level.

However, if the whole building is assessed (existing building + vertical extension), then the final rating will almost entirely depends on the existing building as this one cannot change to meet compliances requirements.

3 Links to design guidance

'Sequence of pre-design' stages need to consider economical and sustainable aspects, especially during the decision process.
In this way, the design guidance proposal is taking into account those both specific items, explaining the advantages of steel technologies for vertical and horizontal extensions.