OPTIMIZATION OF SUSTAINABILITY CONDITIONS OF THE MULTILAYER ENCLOSURE OF "LA CASA SOLAR".

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ABSTRACT

The Polytechnic University of Madrid has designed an industrialized prototype of a single family house, to participate in the Solar Decathlon 2007 Contest. The design objective was the complete energy self-sufficiency in the annual cycle, and become a research platform for the optimization of this objective. Inside the research lines for the optimization of the prototype there is the one that studies the sustainable materials of the house.

We have studied the enclosures of the SD07 prototype to improve the choice of each material involved. The design of the prototype SD0 7 used materials from renewable sources (vegetable fiber panels, OSB), recyclable materials (cold-formed steel), recycled materials (almond shell panels), and material that can be reusable (rolled steel sections, insulation panels, wood panels, floors).

We have carried out a simplified assessment of the sustainable conditions of materials used in multilayer prototype SD07 enclosures. We noted, that overall, the level of sustainability of materials used in the prototype SD07 allows us to improve the characteristics of the sustainable design. We have found the main goal for the development of the sustainability that can incorporate aspects for healthier and more respectful conditions for people and the environment.

INTRODUCTION

Can the choice of materials for the SD07 prototype be improved from a sustainable viewpoint? This question is the starting point and motivation for this study.

The Polytechnic University of Madrid has designed an industrialized prototype of a single family house, to participate in the Solar Decathlon 2007 Contest. This prototype has become a research platform for maximum optimization. Inside the research lines we can find the study of materials from a sustainable viewpoint?

A major effort was made in the choice for sustainable materials in the SD07 prototype, and now the objective is to maximize this choice. As a starting point, materials that respect the environment have been sought on the market, and we´ve found many confusing criteria and even observed how any material can be passed off as environmentally respectful.

This observation has made us go deeper in the analysis that the impact of the materials used in the SD07 prototype enclosure can have on the environment.

METHODOLOGY

Many attempts have been made to establish evaluating methods to objectivise the environmental profile of building materials. These are based on a numbering and evaluating system for the different environmental effects of a material during its life span. These evaluations take into account national and international limits for polluting substances in air, earth and water, which are then added together [1]. Methods include the EPS-Enviro-Accounting Method [2], the Environmental Preference Method [3] and the Ecoscarcity Method [4]

We have established a correlation between the materials used in the SD7 prototype and materials with similar characteristics which are analyzed in different manuals, sustainability guides and the tables are based on available life span analyses and evaluations of building materials carried out in European research institutes [5].

The evaluation tables are ordered so that each function group has a best and a worst alternative for each particular aspect of the environment.

RESULTS

Currently the databases used in the study are the ones available on a European or even world scale which produce errors on occasions on applying European technology or global averages to our country, so in many cases the different inventory databases are not compatible [6].

Even so, to get an initial idea we have begun by carrying out a simplified qualitative life cycle analysis on the materials used in the multi-layered enclosure of the SD07 prototype, supported by different databases.

We shall begin by showing what the materials used were, their position and function in the multi-layered enclosure of the SD07 prototype.

COMPOSICIÓN DE LOS CERRAMIENTOS MULTICAPA

UNIVERSIDAD: *Universidad Politécnica de Madrid*

TIPO: *Cerramiento Vertical tipo 1*

COMPOSICIÓN DEL CERRAMIENTO: | **DETALLE**

CAPA 1 (Ext.):	8 mm Panel Madera de alta densidad PRODEMA
CAPA 2:	40 mm Cámara de aire ventilada
CAPA 3:	Aislamiento térmico reflectivo Polynum 1 Optimer
CAPA 4:	4,5 cm Panel de aislamiento rígido de poliuretano
CAPA 5:	Barrera de vapor Tyvek
CAPA 6:	1,6 cm Panel de OSB ignífugo
CAPA 7:	14 cm Steel frame + 10 cm Aislamiento de fibra natural
CAPA 8:	Vapor retarder
CAPA 9:	1,6 cm Panel de OSB ignífugo
CAPA (Int.):	Acabado final: Panel de almedra o textil
NOTAS:	Diferente cerramiento en baño y cocina

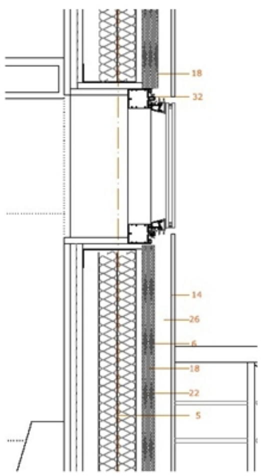


Table 1. Chart of enclosure type of SD07 prototype. [7]

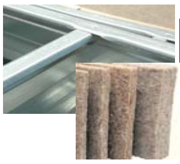
			Materiales análogos	
	Capas del cerramiento (SD7)	*Materiales*	*Materiales (SD7)*	*Materiales bases de datos utilizadas*
	Layer 1	Material 1	High density panel reinforced with cellulose fibers and impregnated with phenolic thermoset resins: Prodema	Hard woodfibre boarding
	Layer 2	-	Air chamber	-
	Layer 3	Material 2	Reflective insulation: Polinum	Aluminium, 50% recycled / Polyethylene (PE)
	Layer 4	Material 3	Polyutherane insulation	Expanded polyurethane (PUR)
	Layer 5	Material 4	Vapor barrier:Tyvek	Polyethylene (PE)
	Layer 6	Material 5	OSB panel	Plywood sheeting
	Layer 7	Material 6	Steel frame	Steel:galvanized from ore
		Material 7	Hemp vegetable fibers	Flaxen matting
	Layer 8	Material 5	OSB panel	Plywood sheeting
	Layer 9	Material 8	Composite material obtained from almond shells which are crushed and mixed with synthetic resins: Duralmond:	Hard woodfibre boarding
		Material 9	Wooden particle board mixed with a preparation of synthetic resins + cotton upholstered finish	Chipboard / flaxen matting
		Material 10	Porcelain ceramic finish: Lammax:	Ceramic tiles

Table 2.Some of the materials used in the SD07 prototype. [8]

We have selected the corresponding information on the materials used in each of the layers of the SD07 prototype, looking for the material that it most resembles to get a general idea of what is happening.

Layer 1 is “a high density panel reinforced with cellulose fibers and impregnated with phenolic thermoset resins and natural wood finish protected with a unique formulation coating and acrylic and PVDF acrylic resins *…” [9].This material corresponds to *Hard wood fiber board with bitumen.*

Layer 3 is made up of a reflective insulation: “Polynum®, made of high density polyethylene bubbles laminated with 100% pure aluminum with an anti-rust HR treatment for aggressive environments” ”. [10]. This material corresponds to *Polyethylene (PE) and Aluminum, 50% recycled.*

Layer 4, corresponds to the polyutherane insulation which coincides in both cases.
Layer 5 contains the vapor barrier: “Tyvek® brand protective material is a family of tough, durable spunbonded olefin sheet products that are stronger than paper and more cost-effective and versatile than fabrics. Made from high density polyethylene fibers, Spunbonded Olefin is an extremely versatile material, offering a balance of physical characteristics that combine the best properties of paper, film and cloth.” [11]. This material corresponds to *Polyethylene (PE)*
Layers 6 and 8 are made of OSB, which corresponds to the analog material found in the databases *Plywood sheeting.*
Layer 7, contains the hemp fiber insulation which resembles the material in the databases *Flaxen matting.*
Layer 9 , is made up of the interior finishings:
- The almond Shell panel “Duralmond is a composite material obtained from almond shells which are crushed and mixed with synthetic resins…” [12]
-The board is used as a backing for the cotton upholstered finish. It´s wooden particle board mixed with a preparation of synthetic resins (formaldehyde) and then pressed….” [13]. This material corresponds to *Chipboard.*
- LAMMAX® porcelain ceramic finish, 3mm thick and with 1000x3000 dimensions.

Next we shall analyze the main environmental variables. The effects on natural resources and effects on contamination have been considered.

					Material resources		*Energy resources*			*Water*
SD07 PROTOTIPE	*Material*	*Technical properties*			*Statistical number of years left as reserves*	*Raw material (see Table 1.1) R = renewable*	*Primary energy consumption (80 % of the total energy imputin a material)*			*Use of water (litres/kg)*
		Weight (kg/m3)	*Durability*	*Loss factor (1) (%)*			*North Europe (MJ/kg)*	*Central Europe (MJ/kg)*	*Combustion value(2) (MJ/kg)*	
Mat. 1	Hard wood fiber boarding	900	medium/high	20	40	R-oil			-7	
Mat.2	Aluminium, 50% recycled	2700	high	21	220	Bauxita	58	184		29000
	Polyethylene (PE)	940	low /medium	11	40	oil		67	-44	
Mat. 3	Expanded polyurethane (PUR)	35	low/medium	12	40	oil	98	110	-76	18900
Mat. 4	Polyethylene (PE)	940	low /medium	11	40	oil		67	-44	
Mat. 5	Laminated timber	550	medium/high		390	R-carbon	4		16	
Mat.6	Steel: galvanized from ore	7500		21	21	iron, zinc	12	25		3400
Mat. 7	Coconut fibre, strips	100	medium			R				
Mat. 8	Hard wood fiber boarding	900	medium/high	20	40	R-oil			-7	
Mat. 9	Chipboard	750	medium/high	20	390	R-carbon	2	4	-14	1000
	Jute fibre, strips	100	medium			R			12	

Mat. 10	Ceramic tiles	2000	very high	18		clay ,for fire products	8	8		400

Table 3: Effects on resources. [1]

Regarding the effects of the use of construction materials on the general resources of the planet, the following parameters have been considered:

- The technical characteristics of the materials, where the following are considered important: weight; durability of materials that leads to a certain degree of maintenance: loss factor, described as the part of the material lost during storage; transport, installation of the final product and loss of material caused by wear on the building due to weather effects.

- The material resources, the number of years left of raw material reserves, and the raw material from which the product is extracted are considered important.

- On the other hand, the source of implicit energy in the material is considered, essentially the primary energy consumption (PEC). This is the energy necessary to manufacture construction materials. An important factor is the calculation of the combustion value of materials, in other words, the amount of energy that the raw material would have produced on being burned as fuel. The PEC is generally around 80% of the total energy contained in the material. The consumption of energy during the construction, use and demolition is usually around 20% of the energy input.

- Finally, the amount of water necessary for the elaboration of the product is considered.

The second important variable considered is related to the effects of contamination, which are shown below:

		Environmental poisons and ozone reducing substance (numbers refer to substances in Table 2.3)				*Dominating air pollution*								
		Health		*External environment*		*Scandinavian peninsular*			*European continent*			*Waste from theproduction process*		*Building and demolition waste*
SD07 PROTO TIPE	*Material (analyse data base)*	*Working environment*	*Interior environment*	*Exclusive of waste*	*From demolition waste*	*GWP(1) (g/kg)*	*AP(2) (g/kg)*	*COD(3) POCp(4) (g/kg)*	*GWP(1) (g/kg)*	*AP(2) (g/kg)*	*COD(3) POCP(4) (g/Kg)*	*g/kg product*	*Percentage taken to special dumps*	*Waste category(5)*
Mat. 1	Hard wood fiber boarding	22-8-2-5		8-2-5-0	8									*B/E*
Mat. 2	Aluminium, 50% recycled	45-22	-	45-22-27		1900	13	3	11102	60	119	715	20	D
	Polyethylene (PE)	25-2-05-0	-	2-5-0-0					751	9	0.1			*B/D*
Mat. 3	Expanded polyurethane (PUR)	33-2-5	-33	14-33-2-5	-33	4800	38	14	3900	30	42	486	7	*B/D*
Mat. 4	Polyethylene (PE)	25-2-05-0	-	2-5-0-0					751	9	0.1			*B/D*
Mat. 5	laminated timber	22-42-2-5		42-2-5		60								*B/D*
Mat.6	Stell:galvanized from ore	22		2-5-15-10-27		1000	4	1	2230	10	840	601	5	D
Mat. 7	Coconut fibre, strips	22												*A/D*

Mat. 8	Hard wood fiber boarding	22-8-2-5		8-2-5-0	8									*B/E*
Mat. 9	Chipboard	22-42-28-2-5	28	42-28-2-5	-42	20	0.3	1	69	1	102	40	2	*B/D*
	Jute fibre, strips Peat slabs	22												*A/D*
Mat. 10	Ceramie tiles	22		27-50	(10-37)				571	4	51	9		C

Table 4. Effects on pollution. [5].

The first four columns only give the potential problems that can arise from these materials, so it is not possible to use them as a basis for any quantitative comparison. Figures in brackets show pollution that is rare or only occurs in small doses - means that there are no known pollution problems. Open space means that there is no available information.

(1) GWP = Global Warming Potential in grams CO2 equivalents; (2) AP = Acid Potential in grams SO2 equivalents; (3) COD = Chemical Oxygen Depletion in grams NOx; (4) POCP = Photochemical Ozone Creation Potential in grams NOx; (5) Waste categories: A: Burning without purification ; B:Burning with purification; C: Landfill; D: Ordinary local authority tip; E:Special tip; F:Extrictly controlled tip.

The contamination types observed are: dust; substances that reduce the ozone layer; greenhouse gases; substances that lead to acidification; the potential of a product to reduce the ozone layer; eutrophication; electromagnetic radiation including radioactivity and radiation in low frequencies that can effect biological processes; the physical encroachment of nature, related to the loss of biodiversity and contamination due to genetic manipulation.

In tables 4 and 5 the effects on health and environment of the type of substance that makes up the materials in the SD07 prototype are described.

2	Aliphatic hydrocarbons (collective name for many organic compounds, naphthenes and paraffins)	Irritates inhalation and oral route and skin; promotes carcinogenic substances
5	Aromatic hydrocarbons (collective name for many organic compounds such as benzene, styrene, toluene and xylene)	Carcinogenic and mutagenic; irritate mucous membranes; damage the nervous system
6	Arsenic and arsenic compounds	Bio-accumulative; can damage foetus; mutagenic; many are carcinogenic
8	Bitumen (mixture of aroma tic and aliphatic compounds, such as benzolalpyrene)	Contains carcinogenic compounds
10	Cadmium	Bio-accumulative; carcinogenic; even in low concentrations can have chronic poisonous effects on many organisms such as liver, kidney and lung damage
15	Chrome and chrome compounds	Allergenic; bio-accumulative; carcinogenic; oxidizing; can cause liver and kidney damage
14	Chlorofluorocarbons (CFCs)	Break down the ozone layer
22	Dust	Irritates inhalation routes; forms part of photochemical oxidants
25	Ethene, ethylene	Possibly carcinogenic because it becomes ethylene oxide in the body
27	Fluorides	Changes in bone structure; damages forests and water organisms; generally poisonous in varying degrees of accumulation
28	Formaldehyde	Allergenic; carcinogenic; irritates inhalation routes; poisonous to water organisms
33	Isocyanates (collective group including TDI, MDI)	Very strong allergenics; irritates mucous membranes and skin
37	Nickel and nickel compounds	Allergenic; bio-accumulative; carcinogenic; extremely poisonous to water organisms
42	Phenol	Carcinogenic; mutagenic; poisonous to water organisms, alkylphenols and bisphenol A are suspected environmental oestrogens
45	Polycyclical aroma tic hydrocarbons (PHHs; group of substances which includes benzo(a)pyrene)	Bio-accumulative; carcinogenic; mutagenic; persistent; particularly damaging to water organisms
50	Sulphur	Acidifying

Table 5. Environmental poisons and ozone-reducing substances in building materials. [1].
Red indicates great danger, orange danger and yellow low danger levels.

The key pollution produced in the Scandinavian Peninsula and Continental Europe is considered. In addition, the percentage of residues in the production of a product is quantified. Finally, the type of residues produced in the demolition phase and the category of waste according to capacity to be burned without producing environmental damage.

The combination of tables 3, 4 and 5 have lead to the environmental preference tables shown below.

Specifically, the vertical structure of an enclosure, steel frame is classified with the degree of intermediate environmental preference (orange color). We also observed that other solutions would be more environmentally favorable (yellow color).

					Effects on resources			*Pollution effects*				*Ecological potential*		Environ mental prolile (Bjørn 2000)
SD07 PROTOTIPE	*Material*	*Compressive strength (kp/cm2)*	*Tensile strength (kp/cm2)*	*Quantity 01 material used (kg/m2)*	*Materials*	*Energy*	*Water*	*Extraction and production*	*Building site*	*In the building*	*As waste*	*re-use and recycling*	*local production*	
	Vertical structures:													
	Aluminium studwork, 50% recycling	4300	4300	5	3	2	3	3	1	2	2	./		3
Mat. 7	Steel studwork, 100% recycling	5400	5400	30	2	1	2	2	1	2	2	./		2
	In situ concrete(2)	150-700	7.5-35	350	2	2	2	3	3	2	1		./	2
	Concrete blockwork(2)	150-700	7.5-35	260	2	2	2	3	1	2	1	./	./	2
	Aerated concrete blockwork, good insulation(1). 12)	30	39937	150	2	3	2	3	1	2	1	./		2
	Light aggregate concrete blockwork, good insulatiod'1.(2)	30	39937	220	2	3	2	3	1	2	1	./		2
	Lime sandstone(2)	150-350	7.5-17.5	220	2	1	1	2	1	2	1	./		1
	Granite, sandstone, gneiss	200-2000	100-320	500	1	1	1	2	2	1	1	./	./	1
	Gabbro, syenite, marble, limestone, soapstone	200-5000	160-315	500	1	1	1	1	1	1	1	./	./	1
	Well-fired solid brick	325	33	220	1	3	3	3	1	1	1	./	./	3(4)
	Well-fired hollow brick	75-150	7.5-15	170	1	3	3	3	1	1	1	./	./	3(4)
	Low-fired solid brick	150	15	200	1	2	3	3	1	1	1	./	./	3(4)
	Earth, without fibres added	40	Up to6	800	1	1	1	1	2	1	1	./	./	1

Softwood studwork[3]	450-550	900-1040	1	1	1	1	1	1	1	1	./	./	1
Pine, pressure impregnated	470	1040	1	2	1		3	2	3	3	./	./	3
Spruce, laminated timber colurnns	450	900	1	2	1	1	2	1	1	2	./	./	2
	400-620	800-1650	1	1	1	1	1	1	1	1	./	./	1

Table 6. Environmental profiles of structural materials. [1].

Notes: (1) Structural materials with high thermal insulation; need little or no extra insulation; (2) Inclusive of reinforcement; (3) A comparison has recently been made by the Norwegian Building Research Institute between timber framed and log buildings. This has shown that log buildings are slightly better than timber framed buildings in use of resources and pollution effects over; (4) Advancing to '2' if in brickwork specially prepared for re-use.

The following table shows the environmental preferences for the insulation materials used in the SD07 prototype, polyurethane and the hemp vegetable fibers. To make the comparison, the materials with the highest similarity from the database have been used.

					Effects on resources			*Pollution effects*				*Ecological potential*		
SD07 PROTOTIPE	*Material*	*Specific thennal conductivity (W/mK)*	*Specific thermal capacity (kJ/kgK)*	*Quantity of materials used (kg/m2 thermal resistance R = 3.75)*	*Materials*	*Energy*	*Water*	*Extraction and production*	*Building site*	*In the building*	*Waste*	*re-use and recycling*	*local production*	Environmental prolile (Biørn 2000)
	Still air	0.024	1.0											
	Water	0.50	1.9											
	Dry snow	0.06~0.47												1
	Expanded perlite, with bitumen, 190 mm	0.055	3 a 4	15	2	2		2	1	2	3			2
	Lightweight aggregate concrete blockwork (structural), 750 mm	0.210	1	560	3	3	2	2	1	1	1	./		3(1)
	Aerated concrete blockwork (structural), 400 mm	0.08	1	200	2	3	2	2	1	1	1	./		2(1)
	Foamglass boards, 170 mm	0.045	1.1	21	2	3	2	3	1	1	1			2
	Foamglass granules, 350 mm	0.07	1	50	1	2		1	1	1	1			1
	Mineral wool, 150 mm	0.04	0.8	3	2	2	2	2	2	2	2	./		2
	Expanded day pellets 430 mm	0.1,15		194	1	3		2	1	1	1	./		2
Mat. 3	Expanded polyurethane 135 mm	0.035	1.5	3.8	3	3	3	3	1	3	3			3
	Expanded and extruded polystyrene 150 mm	0.04	1.5	3.4	3	3		3	1	2	3	./		3
	Expanded ureaformaldehyde, 180 mm	0.05	1.5	5	3	3		3	3	3	3			3
	Compressed wood cuttings 200 mm	0.05-0.09	1.8	24	1	1	1	1	1	1	1		./	1(2)
	Porous fibreboard, unimpregnated, 200 mm	0.05	1.8	60	1	3	2	2	1	1	1			2
	Wood wool slabs, 300 mm	0.08	1.9	69	2	3	3	2	1	1	2	./		2(1)

	Cellulose fibre, loose, 170 mm	0.045	approx 1.8	10.1	1	1	1	1	2	1	3		./	2
	Cellulose fibre, matting, 150 mm	0.04	approx 1.8	11	1	2		2	1	1	3			2
Mat. 7	Flaxen matting, 150 mm	0.04	approx 1.8	2.4	1	1		1	1	1	1			1
	Slabs of peal, 150 mm	0.04	1.2	15	1	2		1	1	1	1			1
	Straw bound together with day, straw >100 kg/m^3, 550 mm	0.12	1.2	330	1	1		1	1	1	1		./	1
	Woollen matting, 150 mm	0.04	approx 1.8	3	1	1		1	1	1	1(3)			1

Table7. Environmental profiles of thermal insulation. [1].

Notes: (1) This material also acts as a structural material, so no extra structure is needed. (2) Thermal insulation varies a great deal with the different types of wood shavings/cuttings. (3) If insecticide is added, much more care must be taken when this becomes waste.

We can see how the materials used in the SD07 prototype are of dangerous environmental preference in the case of polyurethane and for the hemp vegetable fibers the classification is good. The materials in yellow are of high environmental preference.

Finally, in tables 8 and 9 the environmental preferences of exterior and interior finishings are shown.

			Effects on resources			*Effects 01 pol/l/tion*				*Ecological potential*		
SD07 PROTOTIPE	*Material*	*Quantity of materials used (kg/m2)*	*Materials*	*Energy*	*Water*	*Extraction and production*	*Building site*	*In the building*	*As waste*	*re-use and recycling*	*local production*	Environmental prolile (Biørn 2000)
	Stainless steel, from ore	3.8	3	2	2	3	1	2	2	,/		3
	Galvanized steel,from ore	3.7	3	2	2	3	1	2	2	,/		3
	Aluminium, 50% ma terial recycling	1.6	2	3	3	3	1	2	2	,/		3
	Cement-based boarding	20.5	1	2	2	2	1	1	1			2
	Lime sandstone	96	1	2	2	2	1	1	1	,/		2
	Calcium silicate boarding	11	1	1		1	1	1	1			1
	Hydraulic lime render	85	1	2	2	2	2	1	1			2
	Lime cement render	88	1	2	2	2	2	1	1			2
	Gypsum based render	52	1	2	2	2	1	1	2			2
	Stone on steel support system	81	1	1	1	1	1	2	1	,/	,/	1
	Brick	108	1	3	3	2	1	1	1	,/	,/	2
	Timber boarding, without impregnation	13.7	1	1	1	1	1	1	1		,/	1
Mat. 1	Timber	13.7	2	1	2	2	3	3	3		,/	3

	boarding, impregnated											

Table 8. Environmental profiles of external cladding. [9]

			Effects on resources			*Effects 01 pol/l/tion*				*Ecological potential*		Environmental prolile (Bjørn 2000)
SD07 PROTOTIPE	*Material*	*Quantity of materials used (kg/m2)*	*Materials*	*Energy*	*Water*	*Extraction and production*	*Building site*	*In the building*	*As waste*	*re-use and recycling*	*local production*	
	Stainless steel, from ore	3.7	3	2	3	3	1	2	2	./		3
	Cement-based boarding	20.5	1	2	3	2	1	1	1			2
	Lime sandstone	96	1	2	3	2	1	1	1	./		2
	Calcium silicate boarding	11	1	1		1	1	1	1			1
	Plasterboard	11.7	1	2	2	1	1	1	2			1
	Hydraulic lime render	85	1	2	2	2	2	1	1			2
	Lime cement render	88	1	2	2	2	2	1	1			2
	Gypsum based render	52	1	2	2	2	1	1	2			2
	Brick	108	1	3	3	2	1	1	1	./	./	2
Mat. 10	Ceramic tiles	10	1	2	3	2	1	1	2(2)			2
	Timber boarding	8.3	1	1	1	1	1	1(1)	1		./	1
Mat.8	Hard woodfibre boarding	5.4	1	2	3	2	1	1	1			2
	Porous woodfibre boarding	3.6	1	2	2	2	1	1	1			2
Mat.9	Chipboard(3)	7.8	2	1	3	2	2	2	2			3
	Plywood sheeting	4	1	1		2	1	2	2			2
	Woodwool slabs	11.5	1	2	3	2	1	1	1		./	2

Table 9. Environmental profiles of thermal insulation. [1].

Notes: Wallpaper is not included in this table. (1) Pine can give off formaldehyde during a period after fixing. This is most likely because of the drying method that has been used, (2) Certain colour pigments make it necessary to give the material a lower evaluation as a waste product. (3) Chipboard is often covered with a plastic laminate based on phenol or melamine. This reduces the product's environmental profile even more.

We can see how the degree of environmental preference for the materials chosen is low. The exterior finishings of the high density panel reinforced with cellulose fibers and impregnated with phenolic thermoset resins is in red. Inside, in red, the wooden particle board backed by cotton upholstered finish; in orange, the ceramic bathroom finishings and the almond shell finishings. We can see that the recommended environmental preference for the exterior finishings are the calcium silicate, the stone veneer on metal structure and the wooden finishings without impregnation; for the interior finishings the gypsum plaster is preferred.

DISCUSSION

The data shows that overall, the degree of environmental impact with regard to materials used in the SD07 prototype, is intermediate, which gives us a margin to improve the characteristics of the sustainability. The summarizing column contains Biørn (2000) subjective views, so we could come our own conclusions, depending on priority is given to specific environmental aspects, which in turn relate to each particular situation. In any case we have consider the suggestion of the environmental profile in the table below.

			Effects on resources			*Effects 01 pol/l/tion*				*Ecological potential*		Environmental profile (Biørn 2000)
	SD07 PROTOTIPE	*Material*	*Materials*	*Energy*	*Water*	*Extraction and production*	*Building site*	*In the building*	*As waste*	*re-use and recycling*	*local production*	
Panel de madera de alta densidad: Prodema	Mat.1	Timber boarding, impregnated	2	1	2	2	3	3	3		,/	3
Aislamiento rígido de poliuretano	Mat. 3	Expanded polyurethane 135 mm	3	3	3	3	1	3	3			3
Steel frame	Mat. 6	Steel studwork, 100% recycling	2	1	2	2	1	2	2	./		2
Aislamiento de fibra natural	Mat. 7	Flaxen matting, 150 mm	1	1		1	1	1	1			1
Duralmond: panel cáscara de almendra	Mat.8	Hard woodfibre boarding	1	2	3	2	1	1	1			2
Panel aglomerado de madera + textil algodón	Mat.9	Chipboard(3)	2	1	3	2	2	2	2			3
Lammax: panel cerámico porcelánico	Mat.10	Ceramic tiles	1	2	3	2	1	1	2(2)			2

Table 9. Environmental profiles of thermal insulation. [1].

Most of the data shows a major weakness in the presence of dangerous components that are part of the life span of a material and its composition.

To work on the concept of "sustainable materials", in other words materials that satisfy the needs present without compromising or putting at risk the capacity of future generations to satisfy their own, it´s necessary that the materials surrounding us are of higher quality.

It should be emphasized that one of the main criteria for sustainability is to manufacture products without hazardous components. This offers only advantages, as recycling no longer leads to dangerous hybrids and if they are burned for energy or dumped, they are not a threat to the Earth but nutritious for the soil [14].

In light of the data submitted, we see that the choice of materials in the SD07 prototype can be improved form the viewpoint of environmental impact, focusing preferably on "quality" of materials, and incorporating the variables closely linked to people´s health. On the other hand, we´re aware of the limitations that come from working with data produced in other countries, and data on similar materials. These constraints in some cases can remove us from reality. However, the study carried out highlights environmental preferences. It would be advisable to incorporate other variables that define the concept of "sustainability", and represent economy, ecology and equity, in order to obtain more reliable data.

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