MANAGEMENT AND TAKING ADVANTAGE OF RESIDUES IN CONSTRUCTION. NEW EDUCATIONAL CONTENTS INSIDE THE EUROPEAN SPACE OF HIGHER EDUCATION

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ABSTRACT

A current tendency in construction is to have a cycle of life the most possible closed; acting in an optimal form with economy, and in a reasonable form with the environment. Using, in starting point, a first generation material which, after a transformation process, generates an input that once it exhausted its useful life, outcomes the creation of a waste material. If this waste material, after another transformation process, produces a different material (second generation material), and it is inserted again inside another input, the cycle of life of materials will be more efficient and harmonious with the environment.

New trend in the study of the optimal cycle of life of materials, new specifications and environmental requests and the current economic impositions in the construction sector; cause the need to reuse, to design for beyond the common useful life and to apply new second generation materials inside the construction segment [1]

This work presents the content of the subject Management and Taking Advantage of Residues in Construction (GARC, acronym in Spanish), given in the Construction Master of the Upper Technical School of Building (EPSEB, acronym in Spanish) [2, 3] of the University Technical of Catalonia (UPC, acronym in Spanish) [4] The subject is designed to satisfy the necessity to acquire the construction new professional profile, which has to assume competences such as: ecological-social commitment, environmental interest, intuition to research, sustainable inventiveness, etc. [5, 6, 7]

Keywords: environmental impact in construction, materials cycle of life in construction, recycling in construction, reusing in construction, sustainable construction, teaching with environmental matter.

1 NEW THEMATIC CONTENT JUSTIFICATION

The initial studies in criteria of sustainability application in construction (in minimizing processes establishment, design of elements with recycling feasibility, use of recycled materials originated in the construction process or in another industry) promise a viable method to their practice, an energy saving, a big environmental improvement, and a solution for millions of tons of these waste or contaminants that are generated in the European Community, linked in direct or indirect form to the construction activity.

In order to guarantee its possible application, generalized use, legislation or, on the contrary, penalty by noncompliance; it is important to focus on bringing to light this information. This is, introducing it into the construction field in a same level of penetration that other processes or techniques established have; allowing, in this way, that professional of the sector can give answers in an alternative and sustainable form to their needs.

In a specific form, the subject gives the criteria and the state-of-art knowledge in the construction sector for the three "R" of the sustainability (Reduction, Reuse and Recycled). This is achieved, so much in the building segment as in the civil work, like the recent literature documented in books, magazines, articles, internet or practical cases. In a summarized form, the subject is subdivided in four differentiated modules:

1. Reduction and Minimizing: environment versus sustainable development, generation and typologies of residues, residues processing Politics, recycling and materials cycle of life, and residues management.

2. Reuse of materials: general concepts, foundations and retaining walls, structural elements, building exteriors and interiors, and electrical and mechanical installations.

3. Recycled of materials for its application in construction: materials production originated in residues, recycled concrete aggregates for new concretes, use of slag as materials in construction, flying ashes originating in incineration, residues for production of thermal and acoustic insulates, application of sewage sludge, mining industry residues, application of aggregates from demolition in roads, and reuse of tires on asphalt components.

4. Research work: Research of real cases of sustainability practice in construction.

All previous educational work in this subject is adapted to the new educational criteria of the European Space of Higher Education (ESHE); promoting the autonomous learning, the self-learning and the active learning. Likewise, continuous evaluation techniques, self-evaluation and same-level evaluations utilized in the course, are defined in. Finally, the information and techniques before described have been implemented to be available by means of an accessible Virtual Campus in the WEB, based on the data processing system Moodle [8]

2 PROCEDURE

It is important to remark that in the work here developed, it is not exposed in a direct form the innovations referring to the construction sustainability topic; on the contrary, it only uses this topic -already important and innovative by itself- to do a proposal of how would be able to accomplish an approach of a course with construction sustainability thematic content, adapted to the ESHE philosophy. In order to achieve it, we opt to present the curse plan that a registered student receives in this subject, with the different sections, such and as: Subject Overview, Program, Contents and Specific Objectives, Activities and Deliveries Plan, Evaluation System, Evaluation of the Educational Improvement, etc. It is also important to comment that the aforementioned contents, their amplitude and degree of difficulty, are created for Master level students; and they are part of the curriculum block with specialization in construction technical Research, like other thematic sections related to the structural concretes.

3 SUBJECT THEMATIC CONTENTS

The subject general descriptions are shown in Table 1, permitting the student to know the general objectives, the necessary capacities assumed, the educational methodology used in the course, the evaluation system and the consultation material or bibliography. The specific objectives (using evaluative verbs that induce to an action), the taxonomy or classification of the knowledge sought, and the themes related to each objective, are presented in Table 2. Finally, the timetable is presented in Table 3, it indicates what will be done, when and how much time will be dedicated for each activity, specifying the educational methodology to use, and linking the objectives desired to achieve with them.

Table 1. Subject Program.

<table>
<tr><td colspan="2">MANAGEMENT AND TANKING ADVANTAGE OF RESIDUES IN CONSTRUCTION</td></tr>
<tr><td colspan="2">
<table>
<tr><td>ECTS:</td><td>5</td></tr>
<tr><td>Theory:</td><td>2</td></tr>
<tr><td>Practice:</td><td>3</td></tr>
<tr><td>Laboratory:</td><td>0</td></tr>
</table>
CAII – Department of Architectural Constructions II
Responsible: PhD. JOSÉ MANUEL GÓMEZ SOBERÓN
</td></tr>
<tr><td>GENERAL OBJECTIVES</td><td>New trend in the study of the optimal cycle of life of materials, new specifications and environmental requests and the current economic impositions in the construction sector; cause the need to reuse, to design for beyond the common useful life and to apply new second generation materials inside the construction segment. Because of that, the general objective of the course is to give the knowledge of these materials, their possible applications and their economic viability.
The content of this subject intends to give a coherent answer to questions of great importance for the student. These questions are related to aspects such as the knowledge obtaining that allows to adapt the new environmental requirements of the current society to the construction technology, on the one hand, and that contribute with the capacities and competences to be adapted, to propose, to research and to establish new applications that include the concept of recycled component and its use in the construction.
The student has to acquire the competences, dexterities and abilities before presented.</td></tr>
<tr><td>PRIOR CAPACITIES</td><td>1. Generic cross capacities:
-Ecological social commitment.
-Environmental interest.
-Researching and inventive interest and intuition.
2. Specific capacities:
a) Cognitive:
- Basic knowledge of architectural and engineering materials behaviour, such as: processes of environmental degradation, solicitations and minimum requests.
- General mechanic behaviour and physics properties of materials.
- Basic knowledge of architectural and engineering elements construction process.
b) Procedural-Instrumental:
- Variations evaluation and their implication inside the general behaviour of materials used in the construction.
c) Aptitudes-Attitudes:
- Willingness to implement the use of recycled materials in construction.</td></tr>
<tr><td>TEACHING METHOD</td><td>Demostrative master classes.
Active learning.
Self-learning.
Teamwork.</td></tr>
<tr><td>EVALUATION M METHOD</td><td>1. Same-level evaluations.
2. Positive active participation.
3. Inside and outside classroom work. Small deliveries.
4. Exposition of real cases.
5. Multiple answer tests.
6. Co-directed Research works and their exposition.</td></tr>
<tr><td>STANDARDS EVALUATION</td><td>To approve the course, it must be necessary to obtain a grade equal or greater to five in at least four out of the six evaluation methods before described; the four obligatory evaluation methods are 3, 4, 5 and 6. The individual final grade of each student will be the average of the evaluation methods before cited; they are defined in a simple form in the following paragraphs. Final grade = (Same-level evaluation x 0.05)+(Active positive participation x 0.1)+(Inside and outside classroom work, small delivery x 0.2)+(Real cases exposition x 0.15)+(Multiple answer tests x 0.15)+(Research work x 0.20)+(Research work exposition x 0,15)</td></tr>
<tr><td colspan="2">RESOURCES</td></tr>
</table>

MANAGEMENT AND TANKING ADVANTAGE OF RESIDUES IN CONSTRUCTION	
BIBLIOGRAPHY	1. Addis, Bill. "**Building with reclaimed components and materials**". 2006. ISBN 978-1-84407-273-3. Editorial Earthscan. 2. Cheremisinoff, Nicholas P. "**Handbook of solid waste management and waste minimization technologies**". 2003. ISBN 978-0-7506-7507-9. 3. Elías Castells, Xavier. "**Reciclaje de residuos industriales**". 2000. ISBN 978-84-7978-437-9. Editorial Díaz de Santos. 4. Gómez Soberón, J. M, Vázquez, E. y Agulló, L. "**Hormigón con áridos reciclados. Una guía para el diseño del material**". 2001. ISBN 84-89925-80-1. Editorial CIMNE. 5. Gómez Soberón, J. M. "**Comportamientos tenso-deformacional instantáneo y diferido de hormigón con áridos reciclados de hormigón**". 2002. Doctoral Thesis. UPC. 6. Goumans, J. J. M. "**Environmental aspects construction with waste material**": Proceedings 2º international conference environmental implications construction materials, WASCON 94. 1994 7. Goumans, J. J. M. "**Waste materials in construction**". 1997. 8. Zaragoza Bernal, Amparo. "**Reutilización de los residuos generados en obra para la obtención de hormigones**". 2001. ISBN 978-84-7908-515-5. Editorial Publicaciones Universidad de Alicante.
OTHERS RESOURCES	1. Class guides in electronic format, used as support to give the classes. 2. Articles in scientific-technical journals and congresses. 3. Virtual Campus Atenea, with deliverable activities, class forum, message board, evaluative and formative tests, etc. 4. Bibliography available in UPC libraries.

Table 2. Contents and Specific Objectives.

MANAGEMENT AND TANKING ADVANTAGE OF RESIDUES IN CONSTRUCTION					
MODULE		**SPECIFIC OBJECTIVES**			
No.	**Title**	**Description**	**Taxonomy**	**No.**	**Associated contents**
1	REDUCTION AND MINIMIZING	Identifying and to correlate in written or verbal form, the environmental deterioration and the residues generation.	C	1	1.1 The environment and the sustainable development. 1.2 The residues, their generation and their typologies. 1.3 Residues processing politics. 1.4 The recycling and the materials cycle of life. 1.5 Residues management.
		Expressing and to explain the contaminants vectors.	C	2	
		Explaining in written forms, which are the main atmospheric contaminants.	C	3	
		Defining the residue concept, to correlate it with the GNP and with the products of our region countries.	C, H	4	
		Defining and to apply the concepts of minimizing, appreciation and processing.	C, H	5	
		Defining recycling and to establish in written form the limits of the economic and ecological recycled.	C, H	6	
		Establishing flow charts to define the materials cycle of life.	H	7	
2	REUSE OF MATERIALS	Explaining, in written or verbal form, the advantages of reusing construction materials, attending to environmental aspects, of project induced advantages, and advantages for businesses that use them.	C	8	2.1 Reusing general concepts. 2.2 Foundations and retaining walls. 2.3 Structural elements. 2.4 Building exterior elements. 2.5 Building interior elements. 2.6 Mechanical and electric installations of a building. 2.7 Documentary practical cases.
		It will be selected, basing on the advantages, among to develop a recycling in situ or to process to distance materials.	C, H	9	
		It will be able to discern what types and in which situations is applicable to reuse foundation elements.	H	10	
		It will be able to discern in which situations is applicable to reuse a structure or elements of it.	H	11	
		It will be able to discern what types and in which situations is applicable to reuse elements of the building exterior.	H	12	
		It will be able to discern what types and in which situations is applicable to reuse elements of the building interior.	H	13	
		It will be able to discern what types and in which situations is applicable to reuse elements of mechanical and electric services.	H	14	
		Acquisition of the teamwork competences, written and oral expression, documentary Research, etc., assumed for this course.	CT	15	

MANAGEMENT AND TANKING ADVANTAGE OF RESIDUES IN CONSTRUCTION					
3	**RECYCLED OF MATERIALS**	Defining the waste applications from diverse residues.	C	16	3.1 Materials production from residues. 3.2 Recycled concrete aggregates for concretes. 3.3 Use of slag as construction material. 3.4 Flying Ashes originating in incineration. 3.5 Residues for thermal and acoustic insulates production. 3.6 Application of sewage sludge. 3.7 Mining industry residues. 3.8 Use of aggregates originating in highways demolition. 3.9 Reuse of tires on asphalt components.
		Exposing the different techniques of the waste process. Likewise, it would be able to define the applications of recycled materials which content recycled material.	C, H	17	
		Applying the current recycled-material regulations within its objective, resemblances and differences with regard to the most usual materials and reference values of their calculation constants.	H	18	
		Identifying the properties variations of the recycled materials as for their different phases or processes, to their mechanical behaviour or benefit.	H	19	
		Identifying the variations of the recycled materials properties for their durability in general terms.	H	20	
		Determining the application of the dosages design or incorporation of the recycled materials, taking into account the peculiarities of their composition and mechanical capacity.	H	21	
4	**RESEARCH**	Acquisition of capacities: teamwork, written and oral expression, documentary Research, etc.; assumed for this course.	CT	15	4.1 Research work, execution and presentation.

C = Knowledge, H= Abilities, CT = Cross capacities.

EDUCATIONAL IMPROVEMENTS EVALUATION

At the end of the course the questionnaire is delivered (SEEQ) [9, 10], available in the Virtual Campus; at the same time, when some of the activities are finalized, a Questionnaire of Critical Incidents (QuCI) is developed, in order to calibrate possible small immediate improvements.

Table 3. Activities and Deliveries Plan.

#	DIRECTED ACTIVITIES (by professor)								AUTONOMOUS ACTIVITIES			
	CLASSROOM				OUTSIDE CLASSROOM							
	TYPE	DESCRIPTION	OBJ.	DURATION (min.)	TYPE	DESCRIPTION	OBJ.	DURATION (min.)	TYPE	DESCRIPTION	OBJ.	DURATION (min.)
1	Professor exposition.	Demonstrative master class.	1, 2, 3, 4, 5, 6 y 7	150	Individual work outside the classroom.	Reading / synthesis / written expression.	1 y 2	90	Study.	Self-learning.	1, 2, 3, 4, 5, 6 y 7	240
	Individual work inside classroom.	Active learning.	6 y 7	60	Teamwork outside the classroom.	Positive interdependency.	3, 4 y 5	90	Research.	Documented case worked..	15	210
	Put all the presents at the same level.	Dialogue - synthesis.	1, 2, 3, 4, 5, 6 y 7	30	Tutor monitoring.	Theory.	1, 2, 3, 4, 5, 6 y 7	30				
					Evaluation session.	Virtual Campus Atenea.	1, 2, 3, 4, 5, 6 y 7	60				
				240				270				450
2	Professor exposition.	Demonstrative master class.	8, 9, 10, 11, 12, 13 y 14	180	Individual work outside the classroom.	Reading / synthesis / written expression.	10 y 11	60	Study.	Self-learning.	8, 9, 10, 11, 12, 13 y 14	240
	Teamwork inside classroom.	Teamwork.	10, 11, 12, 13 y 14	180	Teamwork outside the classroom.	Positive interdependency.	12, 13 y 14	60	Research.	Documented case worked,	15	1150
	Research work.	Exposition / seminar / evaluation.	15	240	Tutor monitoring.	Theory.	8, 9, 10, 11, 12, 13 y 14	30	Research.	Research work.	15	230
					Documentary Research.	Bibliographical search.	15	60				
					Evaluation session.	Same-level evaluation.	15	30				
					Evaluation session.	Virtual Campus Atenea.	8, 9, 10, 11, 12, 13 y 14	60				
				600				300				1620
3	Professor exposition.	Demonstrative master class.	16, 17, 18, 19, 20 y 21	240	Individual work outside the classroom.	Reading / synthesis / written expression.	19 y 21	60	Study.	Self-learning.	16, 17, 18, 19, 20 y 21	240
	Individual work inside classroom.	Active learning.	18	150	Teamwork outside the classroom.	Interdependence positive.	19 y 21	60	Research.	Research work.	15	1770
	Teamwork inside classroom.	Teamwork.	21	150	Tutor monitoring	Theory.	16, 17, 18, 19, 20 y 21	30				
	Put all the presents at the same level.	Dialogue - synthesis.	16, 17, 18, 19, 20 y 21	180	Documentary Research.	Bibliographical search.	15	90				
					Evaluation session.	Virtual Campus Atenea.	16, 17, 18, 19, 20 y 21	60				
				720				300				2010
4	Research work.	Exposition / seminar / evaluation.	15	240	Evaluation session.	Virtual exposition.	15	30	Research	Research work.	15	720
				240				30				720
INSIDE CLASSROOM TOTAL			**30 hours**	**0 min.**	**OUTSIDE CLASSROOM TOTAL**		**15 hours**	**0 min.**	**AUTONOMOUS TOTAL**		**80 hours**	**0 min.**
									SUBJECT TOTAL		**125 hours**	**0 min.**

ACTIVITIES DEFINITION

Referring to the definition of activities to accomplish in the educational methodologies applied in a course, it is necessary to present all the subject procedure in a written and detailed form; so that the student has a clearly-definite plan that permit him or her to optimize all knowledge acquisition process.

The course is defined in 23 activities to develop (see Table 3). Due to space limitations, here it is not possible to describe each one of them; because of that, only a learning activity definition example is commented in the Table 4. This example belongs to the Synthesis Reading and Expression activity, corresponds to Module 1 of the subject (authors of the work are at the readers disposal to obtain copy of all the others activities).

Table 4. Example of activity to develop by the student.

<table>
<tr><th colspan="10">Activities Plan (1st week)</th></tr>
<tr><td rowspan="2">No.</td><td rowspan="2">Module 1, Activity 1
Reading, Synthesis and Expression</td><td>Class</td><td></td><td>Group</td><td></td><td>Individual</td><td>X</td><td>Duration</td></tr>
<tr><td>Home</td><td>X</td><td>Professor</td><td></td><td>Student</td><td>X</td><td>90 min.</td></tr>
<tr><td rowspan="4">1</td><td colspan="7">Instructions:

Locating an article of Research that "crosses" the following information (keywords):

1. The environment and the sustainable development.
2. The residues, their generation and their typologies.

 

It is an indispensable requirement that the article have ISBN (it cannot be utilized the WEB), it will be taken into account that this article be writing in a different language to the Spaniard.

Read the contained information in the article and perform a small summary synthesis of it (among 70 to 120 words)

Deliver in the Virtual Campus entry of the subject your summary and a copy of the article you worked with (*.PDF)

Load in your class forum your summary; putting at the end a personal criticism to the analyzed content (it will serve you to evaluate your active participation in the forum). If you consider as necessary, you can contribute with information or personal opinion of others students work).</td><td>Objective related to this activity: 1 and 2 of the subject content.</td></tr>
<tr><td colspan="8">Necessary material: This document, the article facilitated in the Virtual Campus of the subject, pencil and paper</td></tr>
<tr><td colspan="8">Delivery: In the Virtual Campus of the subject (also paste the information in the debate forum of the subject)</td></tr>
</table>

Red mark: Maximum value 100/100, minimum value 0/100. The grades average pertaining to all the activities carry out in the course corresponds to the 20% of the final grade.

Criteria to evaluate activity			
Criterion	**Quality levels criteria**		
	Bad-solved criterion	**Special cases**	**Well-solved criterion**
It has ISBN.	(-1 point)		(1 point)
Stems from a source of bibliographical Research.	(-1 point)	Others (-0.5 point)	(1 point)
A PDF copy is delivered.	(-1 point)	Others (-0.5 point)	(1 point)
The summary contains between 700 and 1200 words.	(-2 points)		(1 point)
It is written in not Spanish language.	(-1 punts)	It is written in Spanish (-0.5 point)	(1 point)
A critical reasoning is contributed at the end of the summary as result of a personal analysis.	(-3 points)	Simple ideas, do not concatenate, no contribution in reasoning with basis (-2 points)	(3 points)
It is delivered in form and adequate time.	(-2 points)	Small defects in the form (-1 point)	(2 points)

Note: This activity success is summarized in: to know to work in team, to know to reach consensus and to have ethics and professional morality.

Regards: José Manuel Gómez Soberón

Finally, it is important to comment that in this course, students have class guides and solved examples in PowerPoint format (Figure 1), helping them to obtain a complete information of all the course agenda.

Figure 1. Examples of a class guide and a solved sustainability in construction problem.

CONCLUSIONS

As general conclusions we can mention the following:

a. Developing the content of a subject the most precise, detailed and specific way, facilitates the educational work doing by professor. Furthermore, and important too, students of the subject are able to control, to plan and to know their taking of advantage, their private needs and what it is expected from them, in every moment.
b. The course presentation format here proposed can be applicable to other subjects and contents with particular small modifications.
c. The format and contents here proposed should not be, in any case, static and invariable; on the contrary, these should be adapted and could increase each time the course will be given.

As specific conclusions of this proposal we can comment the following:

a. The sustainability thematic contents should be included in subjects related to construction careers; since its application, the up-to-date needs, and regulations, require it.
b. Professionals with sustainability capabilities will have a more competitive labour profile, adapted to a growing market in sustainability subject matter.
c. The need to instruct the construction sector into the ESHE concept requires, in a coherence way, to promote the sustainability of it, contributing with new thematic contents, current techniques and new solutions to the nowadays challenges we face to.

ACKNOWLEDGMENTS: The authors thank to: Projects Financing Aids for the of the Educational Quality Improvement in the Catalonian Universities for the year 2008 (MQD) by the Agència of Gestió d' Ajuts Universitaris i de Recerca [11], to the Improvement Project Aid to the Teaching Assembly 2008 by the UPC (Sciences of the Education Institute [12]), and to the Department of CAII [13] of the EPSEB of UPC.

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