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Dealing with Construction Waste: Policies and Response

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Abstract
There is an increasing awareness and interest in the need for sustainable construction in many countries. Compared to the high income countries, developing countries might be able to establish socio-economic growth with lower levels of pollution, because of today's global concern and research knowledge about environmental quality and the availability of cleaner technologies. Research carried out in various countries with different development level by scholars at the Eindhoven University of Technology aims at getting a better understanding of response policies and actions as well as mechanisms at work in dealing with construction waste. In Chile -which is an emerging country- the attention for the environment grew the last 10 years, although environmentally sustainable building practices are still in a starting up phase. Sustainable construction became a policy issue in the Netherlands in the 1990s, although the measures to meet the targets of sustainable construction are not adopted on a large scale since then. Major bottlenecks for sustainable construction appeared to be the awareness and interest among the stakeholders. Policies could boost sustainable construction by stimulating the awareness among stakeholders and encourage actions to incorporate sustainability considerations in integrated design, engineering and execution of construction projects.

Keywords: Construction Waste, Sustainability, Construction Industry, Policies.

1. Introduction

Production processes in many sectors of an economy bring about environmental pressure, which has an impact on the state of the environment.The construction sector is one of the largest sectors in terms of resource consumption and waste production in the world. Industrialized countries have achieved substantial improvements in environmental quality while they experienced economic growth at the same time (World

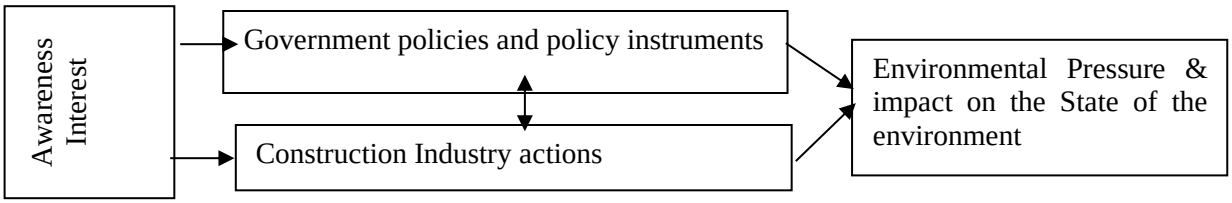
Bank 1992). Various case studies showed an inverted-U relation between income growth and emission in countries. This suggests that during the first stage of industrialization, emissions will rapidly increase. The balance shifts as income rises, with the result that people attach increasing value to the environment, regulatory institutions become more effective and leading industrial sectors become cleaner. Agenda 21 for sustainable construction in developing countries (DCs) shows the increasing interest in sustainable construction in these countries as well (Plessis 2002). DCs might be able to establish economic growth with lower levels of pollution compared to the high income countries because of today's global concern and research knowledge about environmental quality and the availability of cleaner technologies. DC's differ in many respects, not in the least place in terms of their socio-economic development status as well as in terms of environmental performance. To get some understanding of the nature and effect of the response policies and actions as well as mechanisms at work in dealing with construction waste case studies were carried out in Chile -an emerging DC- and in the Netherlands.

2. Methodological approach

Various approaches and many tools are applied to describe and quantify aspects of environmental sustainability in the construction industry. Some authors focus on construction management, thereby emphasizing waste minimization (Langston & Ding, 2001, p.22). Others use the life cycle approach in research on the environmental impact of the different phases of the total building life cycle. (Anink, et al. 1998, p.12-13; Petrossian & Johansson 2000, p.4; Watuka & Aligula, 2002/3, p.4). The lines of thought behind the so-called Pressure-State-Response (PSR) framework, developed by the OECD (OECD 1993) gave rise to carry out research projects at the Eindhoven University of Technology on the response policies and actions taken by government agencies and the major actors in the construction industry (architects and contractors) as well as the mechanisms at work in dealing with construction waste in the construction industry. The PSR framework states that *pressures* on the environment -such as pollution emissions or land use changes- are caused by human activities – such as production in industry, agriculture, construction, etc-. This can have an impact on the *state* of the environment (air, water, land, living resources) such as changes in ambient pollutant levels, habitat diversity, water flows, etc.). Stakeholders in society – governmental agencies, enterprises, households, etc- then can *respond* to changes in pressures or state with environmental and economic policies and actions to prevent, avoid or reduce the pressure and impact on the state of the environment. Government response is defined to include policies and policy instruments, that facilitate, stimulate and regulate the actual environmental protection process. Policy instruments include *(a) Direct regulations* ('command-and-obligation' measures, laws and norms); (b) *Indirect regulations* (regulation of energy prices & taxes; charges for waste disposal; technical & financial assistance) and (c) *Self-regulatory instruments (*Agreements between government and construction industry; provision of information in order to achieve automatic/ voluntary positive change in environmental behavior*)*

Industry response is defined to include actions and measures taken by architects & contractors that directly reduce the environmental pressure. This is investigated by looking at the application of *environmental considerations in (a) the design process* (energy, and waste & material considerations in design, and application of energy saving measures)*; (b) the construction process* **(**waste & material considerations on site) as well as by investigating *innovation in construction* (Rates of waste recycling and recovery as a percentage of total construction & demolition waste generation; Implementation of clean production technologies*).* Government policies influence the Construction Industry practices. Possible barriers for effective response policies and actions to achieve sustainable construction are assumed to be a result of the environmental awareness and interest among the government officials, architects and contractors. Indicators of the response policies and actions were found, developed and derived from various publications such as reports of OECD (1993-2000) and Yuri et al (1999).

Figure 1 A conceptual model to investigate response policies and actions



The above described methodological approach is applied in case studies carried out by the authors at the Eindhoven University of Technology in close collaboration with professionals in the Netherlands and overseas. In the following a summary is presented of the major findings of studies in Chile and the Netherlands. Data collection took place by means of literature studies, expert opinions as well as by means of questionnaires. Key persons at government agencies were interviewed by means of semi-structured focused interviews. Additionally a survey has been carried out in Chile to investigate the attitudes and opinions regarding sustainable building of contractors/ construction companies, and architects. The purpose of the survey was to obtain a general picture of the environmental building practices of architects and contractors during the last three years. In addition, it should give an insight in the efficacy of the current policy instruments. The survey was limited to the contractors and architects in the Santiago Metropolitan Region (SMR). Approximately 75% of all construction companies in Chile is active in this region. The yellow pages were used to compile a list of 200 architects and 1100 contractors to whom a questionnaire was sent. From the latter a systematic sample with an a-select starting point was taken, which resulted in a list of 187 contractors. The response to the questionnaires is indicated in the table. Those enterprises that are involved in civil engineering works are left out. The representativeness of the sample and response to the questionnaires has been controlled by looking at the annual operational value as well as the size of the firms. The outcome came very close to a normal distribution. This outcome is checked with the estimations found in literature and discussed with Chilean professionals (Serpell et al, 2003). Frequency statistics and sum scores combined with confidence analysis have been used to make up conclusions.

Table 1: Overview of the response to the survey in Chile

	Architects		**Contractors**		**Total**	
	Freq.	Perc.	Freq.	Perc.	Freq.	Perc.
Total sent out	200	100%	187	100%	387	100%
Response	38	19%	40	21%	78	20%
Active in building construction	*35*	*92%*	*36*	*90%*	*71*	*91%*

To get some idea of the nature and effect of environmental response policies and actions for and in the construction industry Chile at global level, the state of art of these in the Netherlands were investigated. The data from the Netherlands were largely derived from literature studies complemented with a number of interviews with key persons dealing with environmental issues in the Dutch construction industry.
The data are merely of descriptive nature and meant as a first assessment of how the construction industry in countries with a different development status deals with the environmental impact of its activities. It is in the line of the research intention to carry out more and more in depth studies by using the same methodological approach.

3. Response policies and actions in Chile

Rough investigations of the environmental pressure by the Chilean construction industry – measured in terms of CO_2 emissions per unit of cement production- compared with per capita production growth in this sector show that from 1983 onwards a relative "de-linking process" has taken place. Emissions grew at a

lower rate than construction GDP. (Pluk, M et al 2003) This seems to indicate the existence of response policies and/or actions taken by the stakeholders in the construction industry to reduce the environmental pressure and impact.
The results of the literature study as well as the interviews regarding the *Government response in Chile* however tell that the Chilean environmental policies only by the narrowest margin are related to the construction industry. The current legislation refers merely to the reduction and prevention of dust (particular matter), noise, and solid waste by construction processes.
The most important *direct environmental policy measures* encompass the realisation of specific construction & demolition (C&D) dumps, the obligation to carry out an environmental impact assessment (EIA) of construction projects and regulations regarding energy efficient housing construction. The last are included in the Chilean Building Code. Although there are no specific norms or regulations for C&D waste, the government has acknowledged the problem of illegal dumping and allocated four locations for C&D waste dumps in the Santiago Metropolitan Region recently. The energy regulations as yet only concern the roof design of houses. *Indirect policies* such as pricing & tax policies are non-existing in Chile. Opinions of the key informants who were consulted differ regarding the possibilities for the application of indirect policy instruments such as pricing & tax policies. Important barriers are mentioned to include (a) the existing articles in the Constitution regarding general taxes and (b) the lack of knowledge on the implementation of economic instruments at policy level in Chile. Policy measures meant to stimulate *self-regulation* to achieve sustainable construction practices include the following. The Chilean government facilitates construction firms -particularly firms in the Santiago Metropolitan Region- which confirm their adherence to sustainable practices by means of signing a Clean Production Agreement and become certified accordingly. This implies that construction companies commit themselves to the agreement and give specific attention to avoid or decrease environmental pollution by construction dust (particular matter), noise, and solid waste. Next to this the government provides information via various governmental agencies to increase the environmental awareness among construction firms for example by means of demonstration projects, alike the three projects of the Ministry of Public Works. With these projects is shown how environmental aspects can be integrated in the design phase. The Chilean Construction Chamber provides information to construction firms as well in the form of three manuals on how to minimise construction dust, noise, and solid waste. Financial assistance from the government for the improvement of environmental sustainability of construction practices is only limited available.

The results of the survey among architects and contractors to assess the response of the construction industry to environmental pressure and impact of its activities show the following. Some 54% of the architects mentioned that they are taking environmental aspects into account while designing, thereby focusing on energy issues rather than waste and material considerations. 40% of the contractors mentioned that they take environmental aspects such as material waste, use of water and energy and air pollution (dust and noise) into consideration while carrying out a construction project; 64% of the contractors indicated that they apply a noise reducing technology at present and 78% of them implemented at least one technology to reduce construction dust during the last three years. Waste and energy reduction measures were taken by respectively 20% and 11% of contractors during the last three years..

The effect of the governmental environmental policies on the building practices appeared to be limited. This conclusion is based on the following survey results. Some 40% of the architects mentioned to have contributed to an environmental impact study during the last three years, whilst 33% of the contractors did so. The execution of an environmental impact study – for which the owner of the building has the responsibility- is obligatory to get a building permit for most projects, except for individual residential buildings. Architects who are in majority involved in residential building projects contributed less to such studies compared to those who predominantly carry out building projects for the industry or services sector (hospitals, schools, etc). Unfortunately no more detailed data were available to give a more precise indication of the actual effect this policy measure. Key informants indicated that the obligation to carry out an EIA of each construction project in practise only takes place at a limited rate.

Given the fact that energy efficiency regulations have been included in the Building Code – although restricted to the roof construction of residential buildings so far- 90% of the architects mentioned to have given particular attention to roof insulation. Although the question is rather sensitive to social desirability, the respondents have been asked to what extent they meet the environmental norms. The answers though indicate that only 33% of the respondents consistently meet the norms.

The Chilean Chamber of Construction has been promoting the recycling and recovering of construction waste in line with the government response to avoid illegal waste dumping, which resulted in the creation of a recycle company named REGEMAC, owned by 52 construction firms.

82% of the architects and 56% of the contractors makes use of the information on environmental issues provided by the government and governmental agencies such as the Ministry of Public Works, Municipalities, Technical Institutes and Innovation Centres. Most information that is acquired concern norms and regulations. For the architects universities, and innovation centres are the most important source of information, whilst for the contractors it is the Chilean Construction Chamber.

Many contractors (78%) indicated their intention to sign the clean production agreement and the intention to become ISO 14001 certified. 22% of the contractors answered that they did no (yet) commit themselves to any of these. For the architects the situation is different. Some 59% of them answered that they do not commit themselves to voluntary actions such as the inclusion of sustainable design in the mission statement of their firm or putting forward a request to a contractor who is going to carry out the construction project to present a waste treatment plan.

This attitude can be explained by the following survey results. Architects mentioned to give less priority to environmental aspects in the design process compared to other aspects like costs –first priority- , followed by functionality and esthetical aspects, which determines the choice of materials. On the other hand the survey results show that architects consider themselves most responsible for sustainable construction followed by the owners and next the contractors. Architects also indicate that they have a higher level of knowledge and interest in sustainable construction compared to contractors, owners, real estate agents or building material suppliers. Also for contractors the first priority is given to cost aspects, followed by the clients requirements and choice of materials with least environmental impact. According to the contractors the owners are the most responsible group for sustainable construction and they also are perceived to have most interest in sustainable construction. The contractors consider themselves the next responsible group followed by civil servants. Although both architects and contractors do not give a first priority to environmental aspects, they seemingly share a feeling of responsibility regarding the possible environmental pressure and impact of their construction activities.

Awareness is the major driving force for sustainable construction according to the architects followed by the need to meet regulatory requirements, whereas the contractors mention their interest in getting a respectable image in the market as the major driving force for sustainable construction, followed by environmental awareness and the need to meet the regulatory requirements. Although rather obvious the survey appears to show a positive relationship between the degree of importance given to sustainable construction by the firms and the environmental sustainability of their practices.

The major barriers for non-sustainable construction are according to both architects and contractors the lack of government support and bureaucracy. Least important –although mentioned in the survey- are their own lack of interest, organizational culture and lack of time. A lack of attention to environmental issues in the educational system of Chile is also perceived to be an important cause of the current construction practises. Furthermore financial and market constraints were mentioned as well as the short-term – project bound-thinking in the construction industry versus the long-term stretch of sustainability.

The key-persons who were interviewed on environmental policies and actions in Chile also point at a lack of awareness and knowledge in Chile in general as well as in the construction industry and a lack of interest at policy level for environmentally sustainable building practices. The National Commission of the Environment does not prioritize measures to stimulate sustainable construction and the control mechanism to enforce legislation apparently is not adequate. There appears a lack of overview regarding the rules applicable for the construction industry. An overall conclusion is that insufficient *environmental awareness* among both the government agencies as well as the actors in construction industry is detrimental to adequately dealing with sustainable construction.

4. Dutch response policy

In contrast to the situation in Chile, sustainable construction became a true policy issue since 1990 in the Netherlands. Developments in sustainable construction, mainly in the application of eco-technologies, have rapidly taken place since then, strongly supported by the government. (VROM 1995, 1999). Sustainable building policies were developed in close collaboration with the actors in the construction industry. An important characteristic of the Dutch Sustainable Construction policy (DuBo, which is an abbreviation of sustainable construction in Dutch) is the mix of policy instruments. The national and municipal government authorities mostly stimulated sustainable construction by using indirect- and self-regulation policies. The indirect policies encompassed subsidies and fiscal measurements, such as an increase in dump tariffs and an official ban on the dump of combustible and reusable C&D waste since 2000 (www.rivm.nl).. This stirred a rather is high percentage of recycling and reuse of construction & demolition (C&D) waste in the Netherlands and the strong increase of reuse of waste. In fact, this involves only the reuse of rubble granules in concrete, replacing sand and gravel. Today, 95% of total C&D waste in the form of stony material is reused in this manner. In addition, a significant amount of timber is reused. The most important examples of self-regulation were demonstration projects, in which sustainable building is put in practice, as well as the National DuBo Packages. Guidelines related to waste & material management are presented in these packages to guide the players in the construction process. By means of the demonstration projects and experiments designers were pointed to the opportunities of Industrial, Flexible, and Demountable (IFD) building methods in order to achieve waste minimization and efficient material use. The packages were mainly applied in the form of DuBo-contracts in which agreements were made between municipalities and private companies to adhere to the DuBo packages. Although the packages have been useful their biggest weakness is to be found in the rather detailed prescription on how to implement measures of sustainable building. Freedom in design and construction was gone, provoking resistance among the building industry.

The Energy Performance Norm (EPN 1995), is a direct regulation instrument, being part of the Building Code (VROM, 1997, p.34). The EPN represents a total set of performance requirements regarding the energy efficiency of a building. The freedom for owners, architects and contractors in how to achieve a set target makes this policy instrument highly appreciated by the industry. The result of these measures is that all newly built houses are fully insulated. The Energy Performance Advise (EPA) is a self-regulation instrument. This is instrument was developed to stimulate energy saving measures in the existing building stock. Private individuals can receive an advice and subsidies to save energy in their building. More than 25% of the total building stock has various types of insulation. (www.rivm.nl).

The strength of the Dutch DuBo-policy was the combination of various policy instruments. Government support however was an absolute condition to create awareness for sustainable building in the Netherlands. Moreover the actual results in terms of reduction of environmental pressure are less significant. At the moment, only a small part of the construction industry uses sustainable building as a mean to distinguish itself and the e*xisting sustainable building measures are not adopted on a large scale* (Bueren 2001, p.1-2) The learning effects of demonstration projects are too small and often the DuBo projects are not evaluated. If so, the results are not widely communicated. A major weakness of the response policies in the

Netherlands during the 1990s appears to be the "pamper approach": too many prescriptive rules and subsidies. After the years of promotion and stimulation of environmental building practices during the 1990s, the Dutch government has decided to chance this policy line into a more commercial approach. From 2004, the market is supposed to pick up the phenomenon of sustainable building (van Hal, 2002, p.7).

5. Conclusions

The above described studies form the first steps in a research that is intended to include a series of case studies on sustainable construction. With the wisdom of the availability of limited results at present the following conclusions are drawn. Policy plans could boost sustainable construction which involves a decrease of resource consumption and waste production by the construction industry. However experiences in the cases that were investigated show that environmental awareness and interest -in both an emerging developing country like Chile as well as an industrialized country like the Netherlands- still is not as widely spread as desirable for sustainable construction. An unfamiliarity with the application of environment friendly technologies and the execution of sustainable construction that takes place only with strong government support appeared to be the reasons for the existing situation. Policies and policy instruments which are put in place in a mixed, coherent and complementary way showed to be effective in the Netherlands to a certain extent.. Further could be concluded that regulations should be clearly defined and there should be an adequate control mechanism. Information is indispensable to increase the awareness and interest. However to achieve the adoption of sustainable construction behavior it is essential to accompany environmental gains with economic gains for the actors in the construction industry as well as social gains in terms of health improvements. A solution to ascertain that the market picks up the responsibility for environmentally sustainable construction on a large scale, could be found in policies which , from the start, encourage innovative integral design, engineering and execution of construction projects . This thought leans back on the innovation theories, which learn that innovation and the diffusion of novelties- such as new ideas and technologies for sustainable construction practices- highly depends on a sustainable strong collaboration between the stakeholders in an innovation system. Collaboration in construction however is generally project bound, not long lasting and the responsibilities are often not clearly perceived. Policies thus should incorporate incentives for the industry to establish strong sustainable collaboration commitments between the stakeholders – designers, engineers, building materials industry, contractors and clients- who jointly share the efforts and investment in sustainable building as well as the gains of it in terms of environmental, economic and health improvement. It is thereby important that the environmental policies are not constraining the autonomy of decision-making by the construction industry on how to achieve certain sustainability targets.

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