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PRODUÇÃO MAIS LIMPA EM CONTEXTOS DE MINERAÇÃO E CONSTRUÇÃO CIVIL: RECICLAGEM DE RESÍDUOS SÓLIDOS

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CAMPOS DOS GOYTACAZES/RJ

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Dissertação intitulada Produção Mais Limpa em Contextos de Mineração e Construção Civil: Reciclagem de Resíduos Sólidos, elaborada por Fausto Balloni e apresentada publicamente perante a Banca Examinadora, como requisito para obtenção do título de Mestre em Engenharia Ambiental pelo Programa de Pós-graduação em Engenharia Ambiental, na linha de pesquisa Desenvolvimento e Sustentabilidade e área de atuação Meio Ambiente e Materiais do Instituto Federal de Educação, Ciência e Tecnologia Fluminense.

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RESUMO

Esta dissertação aborda no aspecto qualitativo, duas áreas de atuação que podem contribuir de forma eficaz com o conceito de Produção Mais Limpa (P+L): a indústria de mineração e a indústria de construção civil. Em dois artigos serão enfocados assuntos de conteúdo relevante para a mitigação dos problemas ambientais decorrentes das construções, da produção sem planejamento e da utilização de técnicas rudimentares que acarretam, inclusive, uma grande perda de competitividade no mercado, como é o caso da indústria de mineração de pedras ornamentais de Santo Antônio de Pádua. A reciclagem de resíduos da construção civil (RCD) com utilização na técnica de preenchimento de tubos de aço para a execução de estruturas, serão objeto de atenção especial , atendendo ao clássico conceito de P+L, que subdivide a reciclagem de materiais em duas categorias: reutilização na própria indústria geradora e reciclagem com orientação de resíduos para utilização em outros processos.

Palavras chave: P+L. Resíduos. Reciclagem. Pedras ornamentais. Concreto.

RESUMO

Esta dissertação aborda no aspecto qualitativo, duas áreas de atuação que podem contribuir de forma eficaz com o conceito de Produção Mais Limpa (P+L): a indústria de mineração e a indústria de construção civil. Em dois artigos serão enfocados assuntos de conteúdo relevante para a mitigação dos problemas ambientais decorrentes das construções, da produção sem planejamento e da utilização de técnicas rudimentares que acarretam, inclusive, uma grande perda de competitividade no mercado, como é o caso da indústria de mineração de pedras ornamentais de Santo Antônio de Pádua. A reciclagem de resíduos da construção civil (RCD) com utilização na técnica de preenchimento de tubos de aço para a execução de estruturas, serão objeto de atenção especial , atendendo ao clássico conceito de P+L, que subdivide a reciclagem de materiais em duas categorias: reutilização na própria indústria geradora e reciclagem com orientação de resíduos para utilização em outros processos.

Palavras chave: P+L. Resíduos. Reciclagem. Pedras ornamentais. Concreto.

ABSTRACT

This paper presents a qualitative approach in two areas of expertise that can contribute effectively to the concept of Cleaner Production (CP): the mining and construction industry. In two articles will focus on the issues relevant content for the mitigation of environmental problems resulting from the construction, planning and production without the use of rudimentary techniques that cause even a large loss of competitiveness in the market, such as the mining industry ornamental stones of Santo Antônio de Pádua. Recycling of construction waste (CDW) using the technique of filling steel tubes for the execution of structures will be the subject of special attention in view of the classical concept of CP, which subdivides the recycling of materials into two categories : reuse in the industry itself oriented source and waste recycling for use in other processes generated.

Keywords: CP. Residues. Recycling. Ornamental Stones. Concrete.

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APRESENTAÇÃO

O presente trabalho se desenvolve segundo dois aspectos ligados às questões ambientais: produção mais limpa nas indústrias, enfocando especificamente a indústria de mineração na região oeste fluminense e o aproveitamento de resíduos de construção e demolição na indústria de construção civil, com aplicações em novos conceitos estruturais.

Foram publicados dois artigos, em inglês, em dois congressos internacionais diferentes: o *4th International Workshop Advances in Cleaner Production*, ocorrido em São Paulo em Maio de 2013 e o *5th International Seminar on Evironmental Planning and Management*, ocorrido em Brasília em Outubro de 2012.

PRODUÇÃO MAIS LIMPA

A melhora do nível de qualidade do meio ambiente bem como o controle da poluição atmosférica e o aperfeiçoamento da gestão de resíduos, são quesitos fundamentais para um programa de proteção e evolução no índice de desenvolvimento sócio ambiental das grandes cidades. Diante das carências e dificuldades da vida urbana atual, é necessário que se dê a essas questões um tratamento mais condizente com a seriedade e a eficiência que elas merecem. Ao mesmo tempo, deve-se ter em conta que os processos de implementação de uma produção industrial mais limpa não se contrapõem em absoluto ao nível exigido de competitividade das empresas, pelo contrário, vêm se unir adequadamente a um esforço de otimização produtiva.

Por décadas, a partir da revolução industrial no século XIX, o tão almejado crescimento econômico acabou por promover um processo perverso de deterioração urbana durante todo o século XX, movido por um pensamento enganoso de que no final, com o desenvolvimento econômico e tecnológico, acabaríamos por encontrar mecanismos que seriam capazes de conter, por sí sós, a poluição em vários níveis. Vimos que era uma ilusão, pelo que de fato aconteceu.

Surgem então as ações governamentais, escudadas na autoridade, para ordenar, direcionar ou mesmo inibir o vertiginoso crescimento do processo degradante, através de programas, normas e instrumentos diversos de controle oficial. A iniciativa privada passou então a cumprir com maior ou menor eficácia o ordenamento recomendado, sob pena de pagamento de multas e outras sanções.

A iniciativa de uma atitude pro ativa mais racional na produção das indústrias surge com maior força soménte na primeira década do século XXI. Finalmente as empresas entenderam que o planejamento de uma produção mais limpa atenderia a todos: às empresas, com a otimização nos gastos com materiais e reutilização de resíduos, ao meio ambiente e à população de um modo geral que se livrariam de parte considerável do fardo poluente.

O conceito de Produção Mais Limpa (P+L) surge em 1989, com a expressão lançada pela UNEP (United Nations Evironment Program) e pela DTIE (Division of Technology, Industry and Evironment) como sendo a ampliação contínua de uma estratégia integrada de prevenção ambiental a processos, produtos e serviços, visando o aumento da eficiência da produção e a redução dos riscos para o homem e o meio ambiente.

A indústria brasileira descobre a P+L na década de noventa , após a Conferência das Nações Unidas sobre o Meio Ambiente e Desenvolvimento, a Rio 92.

O objetivo do artigo referente ao título acima foi descrever e avaliar o uso e implementação de tecnologias como contribuição para a P+L na indústria de mineração de rochas ornamentais na região oeste fluminense, através do estudo específico dessa indústria no município de Santo Antônio de Pádua.

RESÍDUOS DE CONSTRUÇÃO E DEMOLIÇÃO

Muitas cidades brasileiras, sobretudo aquelas que apresentam processos acelerados de urbanização, sofrem graves impactos ambientais provocados pela intensa deposição irregular de resíduos da construção civil. Essa grande massa de resíduos, que no Brasil varia de 50 a 70% da massa de resíduos sólidos urbanos, sobrecarrega os serviços municipais de limpeza pública e drena, continuamente, escassos recursos públicos destinados a pagar a conta da coleta, transporte e disposição de resíduos depositados irregularmente em áreas públicas, conta essa que, na realidade, é de responsabilidade dos geradores (MINISTÉRIO do MEIO AMBIENTE).

O início da utilização do RCD ocorreu nos pós-guerra na década de 1940, principalmente na Alemanha, quando cidades foram total ou parcialmente destruídas pelos bombardeiros aliados, mormente no final do conflito. A grande massa de escombros e a falta de espaço para ser utilizada como depósito para os agregados "in natura" trouxe a idéia e a oportunidade de utilização do RCD, solucionando deste modo, o problema da falta de espaço para a deposição dos resíduos e a utilização do RCD, com a conseqüente redução do uso dos agregados naturais (JOHN e AGOPYAN, 2000).

O Brasil possui na atualidade um número crescente de usinas de reciclagem de Resíduos da Construção Civil (RCD), notadamente voltados à britagem de concreto, tendo em vista a boa aceitação desse material no mercado (HABIB *et al,* 2009).

O objetivo do artigo referente ao título acima foi descrever e avaliar, através de pesquisa qualitativa, o uso de agregados provenientes de RCD no concreto de preenchimento de pilares compostos por tubos de aço.

ARTIGO 1

The Impact of the Cleaner Production Technologies in the Mining Productive Chain : The Case of Pádua-RJ

ARTIGO 2

Concrete-Filled Steel Tube Column Using Construction-Demolition Recycled Aggregate

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The Impact of the Cleaner Production Technologies in the Mining Productive Chain: The Case of Padua-RJ

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Abstract

The industry of ornamental stones of Santo Antônio de Pádua, located in the northeast region of the state of Rio de Janeiro/Brazil, is currently the most important productive activity in the region. Despite this, companies make use of simple and rudimentary techniques, which causes serious environmental and competitiveness problems. In order to seek a reasonable sustainability standard for firms operating in the sector, many research, government and civil society organizations have tried to develop and diffuse technologies in order to enhance the industry's competitiveness. However, some difficulties to diffuse technologies, especially to small companies, have arisen. The objective of this research paper is to describe and assess the use and implementation of these technologies as an important contribution for cleaner production and more sustainable approaches and attest that these technologies can represent partial solution for the practice of cleaner production systems in its broader and modern conceptualization. The research study used a qualitative approach and sought to work with multiple sources of evidence such as an extensive bibliographical review, multiple case studies with semi-structured interviews with entrepreneurs and industry professionals, in addition to technical visits to local companies. This paper considers that even with all the effort, the model used to address the lack of sustainability of the firms located in Padua was incomplete and the results were modest. The model was too focused on the technology development itself, but missing other aspects such as training of entrepreneurs and workers as well as the implementation of environmental management systems and adequate set of policies to back up these initiatives..

Keywords: cleaner production technologies, innovation, technological diffusion, mining, productive chain.

1. Introduction

The exploitation of stones in the region of Santo Antônio de Pádua, in the northeast region of the state of Rio de Janeiro in Brazil, is currently the most important economic activity in the region. This sector, according to data from DRM/RJ, comprises about 168 companies (103 quarries, 54 sawmills, 10 sand mines, 1 mineral water source). These companies are responsible for about 5 thousand direct and indirect jobs in the region, which is considered the poorest region in the state of Rio de Janeiro. According to SEBRAE, among the various specialization nuclei operating in the sector of mineral extraction that have been identified in the state, the extraction of ornamental stones in Santo Antônio de Pádua is the most relevant in terms of job generation and income in the local sphere, being very closely resembled to the definition of a Local Productive Arrangement, which is cited in the literature.

In spite of the economic strength of the sector, the mining and cutting operations, in the majority of companies (most of them micro and small sized), make use, until this day, of simple, and even rudimentary techniques, causing uncountable environmental and competitiveness problems. Aware that, even nowadays, the main problems faced by the sector have been related to the lack of a policy framework specific to the mining sector, the use of cleaner production concepts and methodologies could be a feasible alternative for the sector. However, we have been observing a concentrated effort on cleaner production technology development for the mining sector, while other aspects are still missing such as cultural and mindset change and entrepreneurs and workers training.

From 1990 to the present day, there have been many coordinated and uncoordinated interventions from the institutions of the region and the state, in an attempt to develop technologies which could be implemented in the sector. Many of these technologies may be considered successful, because they were able to solve problems faced by the sector. However, the greatest challenge of the research, government and civil society institutions is to understand that only the development of cleaner production technologies is not enough to improve the sustainability performance of the mining productive chain. It is also important to make a deliberate effort to implement cultural and entrepreneurial mindset changes to incorporate more sustainable practices into firms' operations, which can only be achieved with education and training of entrepreneurs and workers.

Therefore, the objective this research paper, given that many specific technologies have been developed and made available for the reduction of problems in the sector, describe and assess the use and implementation of these technologies as an important contribution for cleaner production and more sustainable approaches and attest that these technologies can represent partial solution for the practice of cleaner production systems in its broader and modern conceptualization With regards to the specific objectives, this research paper intends to: describe the traditional processes of extraction and refining of ornamental stones in the region, identify the main problems in all areas of the productive chain; recognize and describe the main technological innovations and their impacts in the sector.

2. Methodology

The research study adopts a qualitative approach since it sought to obtain information and make subjective interpretations about the perspectives of individuals (entrepreneurs, policy makers and industry professionals); thereby aiming to interpret the environment of the supply chain and its problematic with regards to the difficulties of the diffusion of technologies. In order to capture the different points of view on the issue in question, the research study sought to work with multiple sources of evidence such as a comprehensive bibliographical review, semi-structured interviews with entrepreneurs and industry professionals and the participation in various technical visits. This multiplicity of sources of evidence turned out to be vital for the reliability of the results. According to Cauchick Miguel (2010), the most appropriate research methods to carry out a qualitative research are the case study and the action research. But in the case of this study, the researchers had a low degree of involvement with the individuals and organizations surveyed, thus multiple case studies (20) presented itself as the most appropriate method. The interactions took place during the technical visits, interviews, observations and document consultations. The case study is an empirical study that investigates a given phenomenon resulting from multiple sources of evidence, within a real contemporary context (Cauchick Miguel, 2010; Yin, 2001).

The research study began with the definition of a theoretical-conceptual framework by way of a broad literature review composed of articles and technical publications associated with the mining sector in the selected region. Next, a sample of 20 small businesses (from a population of 54 legal sawmills) were selected, from which data was collected (qualitative data; 20 cases) through semi-structured interviews. This approach was adopted so that researchers could gain a better understanding of the processes and problems faced by firms, the innovations and technologies developed and available to firms, and their impact on the sector.

3. The Evolution of the Cleaner Production concept and its use in the mining sector

According to the World Commission on Environment and Development (1987), sustainable development is the "... exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations .... (It is) meeting the needs of the present without compromising the ability of future generations to meet their own needs", several institutions from multiple streams have been trying to achieve social changes through the involvement of all sectors of society in a spirit of shared responsibility, including public administration, public and private enterprise, and the general public (as both individual citizens and consumers). These conclusions and initiatives continue to gain momentum in the last few decades through events such as the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992 and the Rio +20 in 2012. The key conclusion is that economic development cannot be disconnected from environmental considerations. The first initiatives back in the 80's were more focused on pollution control and the introduction of environmental technologies was focused on the prevention of pollutants coming into the air, soil or water, but not on the prevention of the 'production' of the pollutants themselves. The scope of these initiatives has evolved in the last few decades and the literature highlights three major shifts in the development of environmental technologies (Dieleman and Baas, 1991 *apud* Bass, 1995):

1. From pollution control and waste handling technology after pollutant generation, to proactive, process-integrated technology that prevents the generation of pollutants at source.
2. From a sole emphasis upon technological measures to a broader perspective which also encompasses non-technical measures.
3. From consideration of only the environmental aspects of the manufacturing process, to consideration of the environmental aspects of the entire life cycle of products, including product design, sustainable resource management, consumption and post-consumer management of the used products.

A of the most modern perspective conceives a clean environment as a resource, which can be renewable or non renewable. In this way, the renewal of an ecosystem may be more difficult (or impossible) than recovery of a polluted river. With respect to this the World Commission on Environment and Development (WCED, 1987) stressed, on an abstract level, the urgency of meeting the needs of present and future generations in an environmentally sound way. Industrial operationalization of Sustainable Development is being developed via cleaner technologies and products. By sharing responsibilities for the environment at all organizational levels within companies, by substituting toxic compounds and applying renewable energy and environmentally sound technologies, new environmental management instruments are developed. 'Cleaner Production' concepts cover this internalization of environmental effects in new management approaches. (Baas, 1995)

The origin and subsequent introduction of Cleaner Production into the environmental management literature occurred as a result of the work of a band of international agencies in 1989 – namely, the United Nations Environmental Program (UNEP), and United Nations Industrial and Development Organization (UNIDO). However, in most cases, UNEP is credited with having first used the concept, initially defining it as a "preventive strategy which promotes waste before it is systematically created, to systematically reduce pollution, and improve the efficiencies of resource use" (UNEP, 2001, p. 3 *apud* Hilson, 2003).

Baas (1995) defined Cleaner Production as the conceptual and procedural approach to production that demands that all phases of the life-cycle of a product or of a process should be addressed with the objective of prevention or the minimization of short and long-term risks to humans and the environment. The literature is replete with scholarly interpretations and assessments of Cleaner Production. However, despite the multiplicity of interpretations, the concepts of Cleaner Production have evolved substantially. In 1992, the UNEP IE/PAC *Newsletter of Cleaner Production* contained four additional statements designed to answer the question 'What is Cleaner Production?': (Baas, 1995)

(a) Cleaner Production means the continuous application of an integrated, preventive environmental strategy to both processes and products to reduce risks to humans and the environment;
(b) Cleaner Production techniques include conserving raw materials and energy, eliminating toxic raw materials, and reducing the quantity and toxicity of all emissions and wastes;

(c) A Cleaner Production strategy for products focuses on reducing environmental impacts throughout the entire life cycle of the product - from raw material extraction to the product's ultimate disposal;
(d) Cleaner Production is achieved by applying expertise, improving technology and changing attitudes.

Upon analysis, it is clear that these statements represent different dimensions of the preventive approaches of Cleaner Production. During this evolution process, the behavior of the organizations has been changing as well. The attitudes of company leaders towards the environment may be characterized by four different levels: (Baas, 1995)

1. Compliance with present regulations;
2. Receptive anticipation of increasingly stringent regulations;
3. Constructive development of new concepts;
4. Internalization of environmental stewardship thinking and action.

The first two levels can be found among industrial policies and practices. While most company leaders are acting at level 1 or partly at level 1 and partly at level 2, a few companies are evolving and implementing policies and procedures towards level 3. Level 4 is still exceptional; examples of this level are companies with an ecophilosophy. These levels are usually the phases through which a single company develops its environmental policy, as shown in *Table 1* with the trend in new response patterns (Winsemius, 1994 *apud* Baas, 1995).

Table 1: New business approaches toward environmental issues

Response pattern	**Reactive**	**Receptive**	**Constructive**	**Proactive**
Liaison Perspective Participants Consequences	End-of-pipe Specialists Reduction	Process Managers Optimization	Product Industrial sector Quantum jump	Needs Society Vision

Source: Baas (1995)

According to Baas (1995), the most interesting level, and in relation to Cleaner Production the most important, is the 'internalization of environmental stewardship thinking and action', the appropriate vision to integrate the needs within the society with ecologically sound activities. In companies that develop and implement the more proactive approaches of Cleaner Production, a continuous improvement chain is developed which encourages innovations, improves productivity, improves product and service quality, achieves service excellence, increases readiness and survivability, decreases costs and improves the corporate image. However, despite this evidence, even nowadays, in many companies, especially in the mining sector, reactive practices are still dominant, while the new Cleaner Production awareness, which demands new practices and a new paradigm, has not been accepted by them or by most governmental officials.

Despite Ashford's (1994, p. 4 *apud* Hilson, 2003) claim that Cleaner Production "can be applied to the processes used in any industry" and the fact that successful examples of cleaner production and sustainability initiatives in Brazil are not rare (Matos and Silvestre, 2012; Silvestre and Dalcol, 2009), the nature of the mining sector's operations, combined with the inability of its sites to avoid environmental impacts, renders many existing interpretations (of Cleaner Production) highly unsuitable. Another problem is the fact that several interpretations of Cleaner Production appear almost entirely prescriptive for manufacturing and service sector firms. Although there is clearly a need to redefine the concept specifically for mining, few have attempted to bridge this gap in the literature. In addition, Cleaner Production has generally been interpreted in the mining context in an excessively cavalier manner. Most of the assessments made to date have emphasized effect, rather than definition. In the majority of cases, these, and related efforts, merely provide a brief overview of existing definitions of Cleaner Production and describe recent advances in the industry's environmental technology, in turn, leaving the reader to draw a link between the two areas. Few have attempted to describe explicitly how mines can achieve Cleaner Production, as well as how the concept can be both effectively incorporated into national mining polices and embraced at the institutional level. (Hilson, 2003)

According to Hilson (2003), in the mining context, Cleaner Production is increasingly being associated with environmental improvements resulting mainly from technological diffusion and modification; this is evidenced in both the agendas of international Cleaner Production conferences, and industry analysis undertaken by influential institutional bodies. The tendency to view technological change as the sole catalyst for achieving Cleaner Production in the mining industry has, in turn, resulted in its progressive disassociation with the non-technical changes –namely, training, education, and makeshift alterations in managerial practices – capable of facilitating equivalent degrees of environmental improvements.

Hilson and Nayee (2002, p. 22 *apud* Hilson, 2003) argued that Cleaner Production in the mining industry is "a superior level of environmental performance, which can only be achieved through improved strategy and housekeeping, sound process control, optimized plant layout, and the implementation of efficient management techniques". The authors further indicated that attaining Cleaner Production at mines requires adopting a "lateral thinking approach", and "implementing processes and products that are designed from their inception to minimize risks to the environment and human health".

Hilson (2003) argues that if the mining industry is to achieve the targets set out in the UNEP_s general definition (of Cleaner Production) – arguably the most credible interpretation in existence – improved managerial techniques and training programs must accompany the implementation of state-of-the-art environmental equipment at sites. More specifically, technology alone is incapable of "(promoting) waste before it is systematically created ... systematically (reducing) pollution, and (improving) the efficiencies of resource use" (UNEP, 2001, p. 3 *apud* Hilson, 2003) in the mining industry. Hilson (2003) therefore postulated in his paper that, because of the wide range of changes required when applied to mining, Cleaner Production should be viewed as an overarching environmental strategy emphasizing improvements to mining operations and processes, and the adoption of highly effective environmental management strategies. To achieve Cleaner Production, mine management must continuously assess the suitability of input materials, the designs of operations, energy and material inputs, and waste disposal techniques. For the author, Cleaner Production extends beyond the technological and design-related characteristics of the industry, focusing equally upon key managerial and policy-making aspects such as the implementation of management systems, environmental tools and processes; makeshift changes in attitudes; and the application of "know-how" to managerial techniques and housekeeping practices.

The challenge of this paper is to highlight and understand that only the development of cleaner production technologies is not enough to improve the sustainability performance of the mining productive chain. It is also important to make a deliberate effort to implement cultural and entrepreneurial mindset changes to incorporate more sustainable practices into firms' operations, which can only be achieved with education and training of entrepreneurs and workers. In the following sections we introduce the main processes of mining productive chain of Santo Antônio de Pádua – RJ, and the dynamics associated with it as well as the cleaner production technologies and their impacts on the sector. Next, we develop the analyses, which make evident that even with all institutional and organizational efforts, firms and the productive chain did not evolve as expected in terms of sustainability performance due to the use of an incomplete approach to cleaner production.

4. The Mining Productive Chain in Pádua and its Environmental Impacts

4.1 The traditional processes of extraction and refining

The traditional processes of extracting and refining rocks for the production of ornamental stones in the municipality of Santo Antônio de Pádua, that remain in all companies of the region, even those that have acquired new equipment and have implemented innovations, is still little mechanized and mostly handmade. The first activity of the process is the extraction of blocks of rock from the field. The basic extraction technology employed by the majority of companies consists of the detonation of the bedrock, which is very often done rudimentarily (by trial and error), which reduces the economical value of the blocks, because they may present cracks and not uniform edges, and causes severe environmental damages. In a second phase of the extraction, a worker, with the aid of a sledgehammer and chisel, removes small blocks of 50cm x 50cm x 40cm size from the bigger blocks. After the extraction of these small blocks, they are manually sliced into plates by a worker, with the aid of a sledgehammer and a chisel. The stone plates are then transported by truck to the refining companies where they are cut with small saw machines, equipped with a diamond disk, into the fine dimensions of an ornamental stone. Finally, these little plates are once again sliced manually. This procedure produces the end product – the plates of ornamental stone. After the refining, the products generally a commercialized by companies in the region are: Plate, 47 x 47 x 4 cm; Block, 23 x 11.5 x 4 cm; and Brick, 23 x 11.5 x 1.5 cm, or 11.5 x 11.5 x 1.5 cm. (see Fig. 1)

The Severe Environmental Problems Caused by the Traditional Processes

As previously mentioned, due to the lack of technology in the processes described above, the loss of raw material is very high throughout the supply chain. During the extraction the loss might be of about 30%. Besides the economic losses, the loss at this point of the process causes irreversible and severe environmental impact. Once the rocks have been extracted, the extraction area becomes useless, with no alternative use, since the stones are spread on the entire area. During the refining, the problem is even bigger. The loss of raw material may reach 50%. The result of this problem is mountains of debris irregularly disposed in abandoned lands beside the roads of the region. Also during the refining, besides the loss of raw material, there is the release of dust from the stones from the saw machine. This dust, with a very fine granulometry, is inappropriately disposed together with the water used in the process, as mud.

According to Ribeiro et al. (2005), this mud is mostly constituted of water, grit, lime and smashed rock (aluminosilicates, feldspar and quartz), which after the process are disposed in the environment. After the evaporation of the water, the resulting dust spreads, contaminating the air and the water resources. In some cases, the resulting mud is directly channeled to rivers and lakes, causing a serious environmental problem. These serious and recurring environmental problems have caught the authorities' attention since the 1990s. The authorities, through environmental laws, started to fine and close the sawmills and quarries which disposed their rejects inappropriately in the environment.

4.2. The Technological Innovations in the Sector and Their Benefits for the Productive Activities and the Environment

The process of meeting and supporting the manufacturer of ornamental Stones in the region of Santo Antônio de Pádua began in the late 80's, by DRM-RJ (Departamento de Recursos Mineirais do Rio de Janeiro). At that time, the non-articulate action of institutions and local government did not help to minimize the problems in the sector, mainly due to the great expansion in the quantity of production areas and the addition of young miners to the business; all similar to the mining phenomenon. Thus, the implementation of technological innovations was scarce till the mid 90's.

Back in that time, the Serviço Brasileiro de Apoio às Micro e Pequenas Empresas (SEBRAE-RJ) and the Associação de Empresas de Pedras Decorativas (AEPD) were able to sign a contract with the Centro de Tecnologia Mineral (CETEM) in order to try to solve the problems that companies in the region were facing (Almeida et al., 2001). From the problems diagnosed, the CETEM developed works for the improvement of the production of the quarries, especially the aspects related to the extraction of rocks, the safety of workers and the treatment of effluents. These actions, though considered of low impact by some entrepreneurs of the sector, were continued in the project Rede de Tecnologia Mineral – RETECMIN. The RETECMIN was a technology cooperative network for the support of the Productive Sector of ornamental Stones in the state of Rio de Janeiro. This network included: DRM (Departamento de Recursos Minerais), INT (Instituto Nacional de Tecnologia), UENF (Universidade Estadual do Norte Fluminense), UFRJ (Universidade Federal do Rio de Janeiro), CETEM (Centro de Tecnologia Mineral) and FIRJAN (Federação das Indústrias do Estado do Rio de Janeiro). Despite the broad articulation, the RETECMIN was largely criticized by some entrepreneurs for not providing quick and practical results.

Another institution which intervened in the sector in the late 1990's, not involved with RETECMIN, but with other agencies like SEBRAE, FINEP and FAPERJ, was the ETFC – Escola Técnica Federal de Campos, currently known as IFF – Instituto Federal Fluminense. Therefore, after the effort to identify the main problems of the sector, several applicable researches have been developed by institutions of the region aiming to find viable alternatives for the use of residues of the extraction and refining processes of the ornamental stones and for the improvement in the competitiveness of the companies.

The technological innovations made available through those researches and to be used in the supply chain of ornamental stones in Santo Antônio de Pádua can be organized according to Fig. 1. The key cleaner production technologies are described further below.

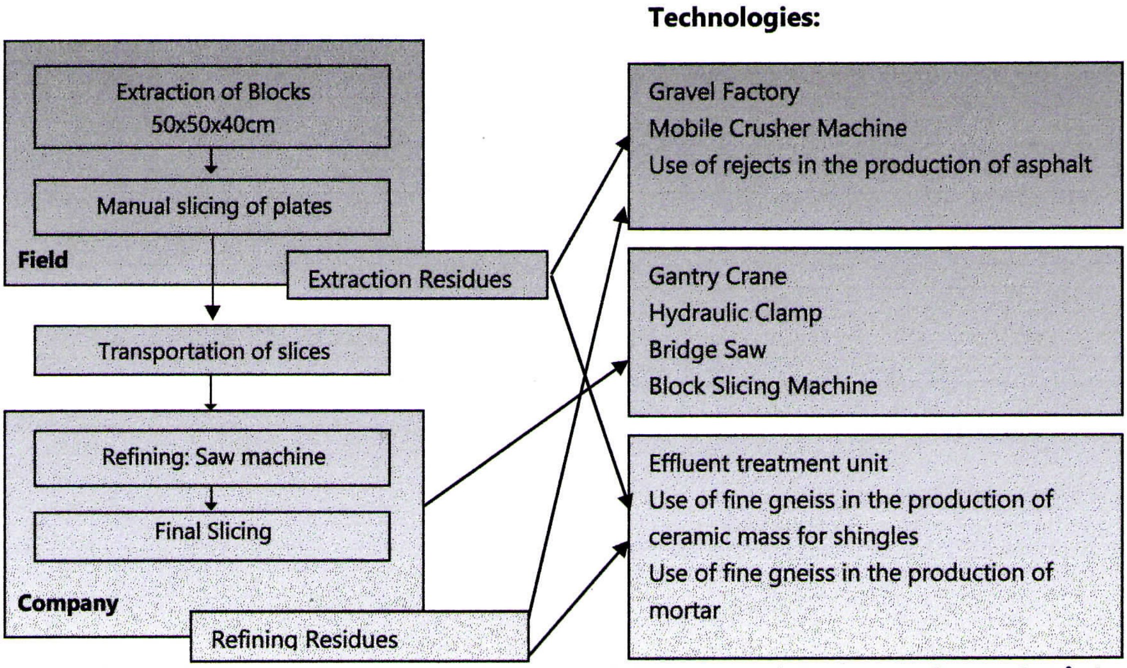

Fig. 1: Available Technologies for the supply chain of Ornamental Stones in Santo Antônio de Pádua.

Segregation of fine solids (Effluent Treatment Units) and their use in mortar for Construction (Mortar Factory): One of the first and most important projects, within the associations of RETEMIN, was the "Segregation of fine solids and their use in mortar for construction", a technology developed by CETEM which proposes the use of fine grained gneiss in the production of mortar. In the first phase of the project, CETEM elaborated a system for the treatment of liquid rejects in order to avoid the disposal of such rejects into the rivers of the region of Santo Antônio de Pádua. The cutting equipment of the companies were, and still are, obsolete since they do not take into consideration the capture and reutilization of water and the fine rejects of the slicing process of stones. These became one of the main legal/environmental problems, due to the intervention of the Public Ministry. At this phase, according to Peiter (2000), RETECMIN was very successful for establishing a simple and low cost process for the collection, cleaning and recycling of water originating from the sawmills – the effluent treatment units, also known as settling ponds.

In the second phase of the project, the researchers searched for alternative uses for the fine solid rejects resulting from the first phase of the project. The results demonstrated that the fine grained gneiss could be used as an alternative to lime in mortar production, a solution achieved by CETEM along with UENF. The study demonstrated the investment's feasibility and caught the attention of the local community and Public Ministry, for the promise of lowering the level of pollution of the Pomba River, which is usually harmed by the disposal of residues (PEITER, 2000). Thus, after the demonstration of the project feasibility and with the support of INVESTRIO, the institutions were able to convince a private group located in the region, Mil Group, to invest in the construction of a mortar factory, ARGAMIL, which is still operating by collecting fine residues of several sawmills.

The Gantry Crane, the Hydraulic Gripper and the Bridge Saw: Another important public intervention in the sector, also outside the sphere of articulation of RETECMIN, happened in the late 1990's, when the so called ETFC – Escola Técnica Federal de Campos, nowadays known as IFF – Instituto Federal Fluminense, supported by SEBRAE and FINEP, developed, for a consortium of entrepreneurs, a group of equipment which allowed a new layout and a new physical arrangement for the unloading of the blocks removed from the field and taken for refining in the sawmills. The first equipment was the Gantry Crane, used to unload blocks from the truck and move them transversally, longitudinally and vertically. In order to develop a gantry crane able to comply with the technical demands of unloading and cutting blocks of ornamental stones, a technological innovation was required – the "Hydraulic

Gripper", a mechanism able to unload large blocks of ornamental stone (SILVA NETO, 1990). Yet, in the sawmill, another innovation adopted by the consortium of companies, was the importation of a circular saw of high precision, also known as bridge saw, which is able to cut large blocks of stone. (Silva Neto, 1990). After the implementation of such equipment, the whole extraction and refining processes was revolutionized, because the unloading of blocks from the trucks and their placement upon the bridge saw, by means of the hydraulic gripper, allowed the companies some other benefits.

Gravel Plant which uses crushed rejects from the quarries and sawmills: The rejects of quarries and sawmills, as mentioned before, are inappropriately disposed along roads or in abandoned lands, causing a significant environmental impact. A technically viable alternative for the use of such rejects consists in crushing such material so as to produce aggregates for construction: gravel stone, sand and dust. In 2010, supported by the Serviço Nacional de Aprendizagem Industrial (SENAI) and funds from FAPERJ, a Gravel Plant was installed close to the Raio do Sol Sawmill, in Pádua. After crushing the rejects, three materials are produced: Gravel 2, which is mainly used in asphalt cement, Gravel 1, which can be used in cement, asphalt and precast, and stone dust, usually used in the production of mortar and precast. The results of analyses suggest that the material is suitable for construction, even though it is limited to small and medium sized constructions.

The mobile crusher machine: Another initiative of IFF, which took place in 2010, was the development of the mobile crusher machine with funds of FAPERJ, through the Technological Innovation Announcement 2010. According to Silva Neto (2012), the project aimed to design, develop and build a mobile crusher machine to process residues originating from both the extraction and refining processes, complying with the technical characteristics of the rocks of the region, with the objective of producing material suitable for paving country roads of the region. This processing of residues, which changes them into sub products for paving, reduces environmental impacts originating from residues disposed at different locations of the region and also increments the availability of raw material for paving the country roads. The greatest advantage of the mobile crusher machine in face of the Gravel Plant is that the equipment can be transported to the places where the residues are deposited so as to crush them at the same location, and placing them close to where they will be used, thus decreasing the costs of transportation.

The slab opener: This ongoing project, is another initiative of IFF and is also supported by FAPERJ, which aims to project, develop and build a "Hydraulic Machine able to slice Ornamental Stone" with the objective of increasing the productivity, reducing waste and improving the quality of end products of the ornamental stone industry. The results expected from this equipment, which is still being developed, are: an increase in productivity of plates, once this process will be performed by a modern and precise equipment; reduction of waste, once most of the handmade cuts will be avoided, causing a reduction in the amount of rejects; and consequently, the reduction in the environmental pollution (Silva Neto, 2011). This equipment is considered by the entrepreneurs as the most important innovation for the sector, because currently the main problem faced by the companies is the lack of specialized workforce able to open blocks into slices.

4.3. Innovation and Technological Diffusion – Challenges for the Padua Mining Productive Chain

The Technological Innovation increasingly assumes the role of the key-resource in the organizations and a source of a competitive advantage. Mueser (1985) defines technological innovation as "a new idea, a discontinuous technical event, which after a certain period of time, is developed until the time comes in which it becomes handy, and is then used successfully." On the other hand, Rothwell and Gardiner (1985) point out that innovation does not necessarily mean the commercialization of only major technological advances, but also includes the use of small-scale changes in technological knowledge. Utterback (1983) suggests that technological innovation is understood as a process that involves the creation, development, use and dissemination of a new product or idea, or the introduction and diffusion of new products and processes which have improved in the economy. Nevertheless, a Technological Diffusion can be conceptualized as the process by which an innovation is communicated over time, through certain channels, among members of a social system (Rogers and Schoemaker, 1971). However, Tigre (2006) states that "the processes of innovation and diffusion cannot be completely separated, because in many cases diffusion contributes to the process of innovation".

Based on the technical visits and the interviews with entrepreneurs of the sector and with professionals of the supporting institutions, it became evident that despite all of the efforts of the institutions to raise funds and to develop technologies to minimize the problems of the sector, these are not widely widespread. Factor such the lack of qualified workforce, lack of market information and the resistance to changes in the company, were the main obstacles to the technological diffusion in the sector (Silvestre and Silva Neto, 2012). In some cases, the economic factor, 'too expensive', was a barrier to diffusion. These factors are defined by OECD (2005) and by Murillo-Luna *et al.* (2001) as barriers to adoption of proactive environmental strategies. However, obstacles such as lack of appropriate funding, hard to control expenditures on innovations, insufficient innovation potential, or even a lack of technological opportunity were not observed during the interviews and technical visits. These results indicate that there is broad availability of public resources for technological innovation, as well as the capacity and initiative on the part of research institutions to develop technologies for companies.

Therefore, the survey results point to the need for interventions to be made in the companies, in view of the fact that the company factors were the main obstacles to the diffusion of technology. In particular, one can highlight the need to increase the level of education and qualification of entrepreneurs and workforce in the sector, as well as to provide specific training with regards to technological innovation. The analyses indicate that these technologies have mainly assisted the large and well organized companies, but their diffusion to micro and small companies is ineffective for many reasons, such as: resistance to make changes in the company and the entrepreneurs lack of access to the research institutions. Furthermore, the articulations try to solve specific problems in the supply chain, without using an integrated approach of the activities carried out in the supply chain. Thus, it is possible to identify the lack of a sector based policy regarding the transference of technology to all companies of the sector, in all areas of the supply chain. This paper argues that development and availability of cleaner production technologies is not enough to improve the sustainability performance of the mining productive chain. It is also important to make a deliberate effort to implement cultural and entrepreneurial mindset changes to incorporate sustainable practices into firms' operations, which can only be achieved with education and training as well as a set of policies to back up the initiative.

5. Cleaner Production in the mining industry

According to Hilson (2003), mining Cleaner Production practices can effectively be divided into three separate categories. The first group, "managerial changes", refers to environmental management-related initiatives that improve the overall efficiency of operations, and which require the participation of staff. Each must be redesigned differently to conventional models, simply because mining consists of four stages (exploration, approval, operational and closure). This, in turn, necessitates the development of a more procedurally complex and comprehensive environmental management strategy. One important "managerial change" – and inevitably, a tool for achieving Cleaner Production – is the implementation of an environmental management system (EMS), which is the component of the overall management system that includes organizational procedures, environmental responsibilities, and processes (Begley, 1996 *apud* Hilson, 2003). Furthermore, regarding "managerial changes" we should also add education and training for employees and managers and organizational commitment to provide direction to employees operating on all levels.

The second group of elements, "policy changes", emphasizes the environmental decision-making aspect of operations. Principal examples include corporate environmental policies, voluntary impact assessments, environmental audits, and reviews. (Hilson, 2003) Specifically, these initiatives seek to identify appropriate technological measures for implementation, as well as areas in need of further improvement. For example, many mining companies have elected to draft environmental policies, which help to provide a much-needed course of direction for activities, covering the areas of operation, environmental assessment, documentation, regulatory compliance, and "ethical" responsibility.

The third, and final, group of elements, "physical changes", include technological modifications, implementation of state-of-the-art equipment, and process - related initiatives. However, the implementation of these and related "Cleaner Production technology types" is a means of achieving pollution prevention, and there are obvious differences between the concepts of pollution prevention and cleaner production, particularly in terms of scope. (Hilson, 2003)

Based on the discussion above regarding the mining productive chain in Padua, we observed that the efforts made by the institutions targeted basically "physical changes" (Hilson, 2003), with the focus on the development of cleaner production technologies. However, significant difficulties were encountered to diffuse these technologies. This fact was observed while no initiative regarding "managerial changes" or "policy changes" was identified during the field studies. We argue that the lack of knowledge of firms and institutions about the cleaner production concepts and methodologies hindered the synergies and the positive effects these technologies could have in the mining productive chain.

5. Conclusion

The concept and methodologies of Cleaner Production have evolved significantly in the last few decades, yet their application in the mining context still remain under the radar for firms and institutions in developing countries. It is not rare institutions, firms and government undertaking an articulated effort with the focus almost entirely on the technological aspects. In Padua, the same thing happened: localized efforts to solve punctual problems in the productive chain, yet no initiative regarding "managerial changes" or "policy changes" were identified. This was in part the result of the lack of knowledge from the actors involved about concepts and methodologies associated with Cleaner Production. We argue that the development of cleaner production technologies is important, but the missing aspects of the approach adopted brought significant drawbacks for the whole initiative. We suggest that a workshop with all actors involved could be a milestone to change the course of the mining productive chain in Padua toward cleaner production and sustainable practices.

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CONCRETE-FILLED STEEL TUBE COLUMN USING CONSTRUCTION-DEMOLITION RECYCLED AGGREGATE

FAUSTO BALLONI

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ABSTRACT

Pillars mixed compounds by steel tubes filled with concrete, are presented as a global trend, in the context of structures for buildings and bridges, being widely used in many Asian countries as well as Europe and the United States. The advantages of this structure are many, if compared with the conventional structures of reinforced concrete, due to the successful integration of the steel shell with concrete confined, which considerably increases the resistance to axial compression set so as to other efforts. Coupled with these advantages are the possibility of using the recycled aggregate from construction and demolition waste in the concrete mix, according to new concepts of cleaner production, which under the effect of

confinement provides a level of compressive strength that we could not if we use the traditional reinforced concrete. In this study we will take into account only the pillars of circular section by presenting a more uniform behavior.

Key words: steel tubes, concrete, construction- demolition aggregate.

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INTRODUCTION

The use of composite columns, or columns which are used in steel profiles covered with non-structural concrete, for the purpose of protection from the weather and fire, it is a well-known practice in the construction. Lately a variant of this system has been gaining ground, which is the use of tubular profiles filled, in which the paper is no longer the concrete coating and becomes again, structural, and the protective paper is transferred treatment technology for anticorrosion and fireproof metal material. In parallel, the global trend of environmental protection through sustainable building practices, such as the use of construction and demolition waste (CDW) and recycled for use in various types of buildings, stimulates the search for new products. Combining these two concepts come to the idea of making a new kind of pillar where, the stage of completion, we could use as aggregate in concrete, recycled material CDW.

The use of tubular steel with the concrete has been used for a long time and is incorporated as a common practice not only large structures such as regular works in urban construction. This system consists of the lining of the tubular profile, whether section square, rectangular or circular, or tubular profiles is not known how the profiles in "I" or "U", dealt specifically with concrete in order to corrosion protection and possible fires. More recently it has been used an inverse process, ie, steel pipes filled with concrete, and in this case, the main intention of taking advantage of their structural properties of the compressive strength axial.

The first experiments in this new process dating from the 1960s in Japan, where Naka, Kato, et al. Developed a first technical testing on

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the subject. In 1985 the Japanese government has implemented a project called New Urban Housing Project (NUHP) with the aim of experimental research to build apartment buildings for the twenty-first century. Since then this technique has been disseminated with increasing intensity presenting very significant advantages.

Alongside the use of CDW as aggregate in concrete production reduces the effects of environmental degradation and scarcity of raw material, since the use of this material decreases the impact both of their deposition directly on the nature and the evils arising from the removal of virgin material. Brazil has today a growing number of such waste recycling plants, notably aimed at crushing of concrete, with a view to good acceptance of this material on the market. By allying the advantages of efficient use of concrete-filled steel tube (CFT) with the concrete with the sustainable use of CDW will be contributing to the dissemination of a constructive system of growing international acceptance but little used in Brazil that still clings almost entirely to the traditional method of reinforced concrete.

METHODOLOGY

Detailed study of the behavior of CDW done with the help of laboratory tests aimed at the compressive strength, particle size analysis, Atterberg limits, density of solids, visual analysis with a

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microscope, compression and shear tests. Analysis of mechanical characteristics of the tubular profile through diagrams of stress and strain, tensile strength and yield, dress rehearsals for both new and steel scrap for parts. Observation of the behavior of the composite with CFT grip tests, the effects of shrinkage and creep, buckling, confinement, ductility, fire resistance and corrosion.

DISCUSSION

As for the advantages of using tubular steel with the concrete, Shosuke Morino, et al cite six major properties listed below:

1 - Interaction between the steel tube and concrete: it provides greater resistance to buckling of the steel tube due to the restrictive effect of the concrete. Furthermore the compression strength of concrete is increased due to the confinement caused by the addition of the steel tube to prevent damage caused by elements for its isolation. The shear stress is decreased considerably compared to the traditional concrete because the effect of slip is contained by the steel shell.

Figure 1 shows the action of axial compression and trends expansion confinement of concrete and the steel tube.

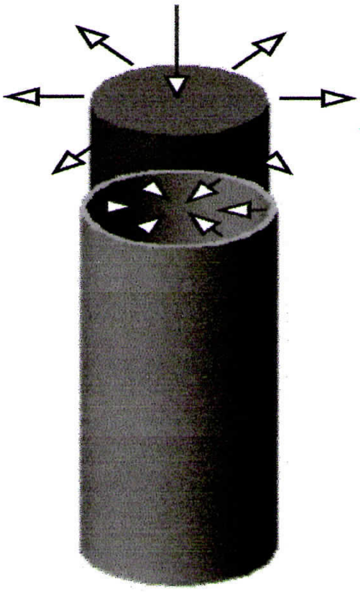

Figure 1 - Axial compression and trends expansion confinement of concrete and steel tube

2 - Properties of the cross section: The cross section of a steel tube filled with concrete CFT has a steel concrete greater proportion than the proportion of reinforced concrete. In addition to the section of steel is well protected against buckling by the fact that lie at the periphery of the section.

Figure 2 provides a visual comparison between the sum of sections of irons with the concrete wall section of the steel tube.

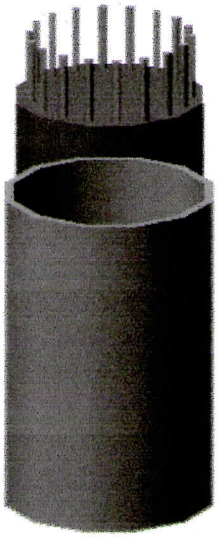

Figure 2 - Comparison between the sum of sections of irons with the concrete wall section of the steel tube

3 - Constructive Efficiency: The building system is more efficient because all the work with shapes, steel or wood, and its reinforcement bracing is omitted and concrete vibrators is made by hand or pumping. Furthermore this system provides a cleaner construction site.

4 - Fire Resistance: The system provides a backbone, or fire-resistant dispensing considerably reducing the use of hazardous materials fire.

5 - Cost: The cost will be reduced due to the advantages listed above.

6 - Ecology: the inconveniences caused to the environment can be reduced with waiver forms of wood, with the possibility of using steel tubes used and the use of aggregates from recycling construction and demolition waste in the composition of the concrete fill.

In the New Urban Housing Project (NUHP), 86 specimens were tested under pillars filled combined efforts (compression and shear buckling). Topics covered in these tests were:

1 - Structural behavior: hardness, effects of confinement, strain, stress transfer mechanisms, ductility and connection to structural steel beams.

2 - Efficiency constructive: Compaction of the concrete, dash, filling method and curing time.

3 - Resistance to fire: Quantity of refractory material.

4- Constructive Planning: Application in tall buildings and costing.

The lessons from these approaches were as follows:

1 - The difference of the relationship between applied load and the compression obtained in the novel process, compared with nominal data, takes place by the effect of containment and is estimated as a function of the resilience of the steel tube.

2 - The creep resistance of CFT a large height can be evaluated by the sum of the resistances calculated for the steel pipe and a concrete column with the same dimensions, separately.

3 - The rate of hardness generally may be evaluated by adding the index of toughness of the steel tube and the concrete. However must be taken into account some considerations regarding the effects of the pressure generated in the tube during concreting, the transfer mechanism of the beams coupled to a column CFT through the wall envelope of steel tube and

drag and shrinkage of concrete. These factors may affect the stiffness of all the new rules that estabelem for concrete and steel in a CFT take into account the increase of concrete strength due to confinement, the effect of scalar relaxation of the tension and increased work reduction of the compressive stress of the steel tube due to annealing, the deformation of the steel tube, the effect of shrinkage of the concrete in the progress of deformation and strain of the steel (Morino, 1998)

BRIDGE & WEBB (1992) also show a type of mounting structure with composite columns filled in stages. It consists of a different technique of concrete pillars which are filled concreted multiple legs at one time from the bottom up through the technique pumped up and into which the concrete fills the tube through the base of the pumping tube, with no need and second vibrating BRIDGE & WEBB (1992) this is the key part of the ease of constructive pillars filled.

PARAMETERS

In Brazil, to standardize the design of composite columns is in the final stages of preparation. Globally, however, this issue has been addressed long ago, and is the main object of research centers, thus creating the first standards of enduring character that will serve as parameters for future experiments. In assessing the strength of a CFT, must be taken into account some parameter settings listed below:

Adhesion.

Confinement effect of concrete.

Strength of concrete.

Slenderness.

Yield strength of steel.

Creep.

Shrinkage of concrete.

Charging mode.

Cross section shape.

Area of the steel profile

Area of concrete section.

Ratio between the areas.

Some of these parameters affect more and others less in the final strength of the pillar. The evaluation of the interference of each of these parameters is laborious and therefore impractical for direct application in design. Several studies have been developed aiming to evaluate the interference of these parameters through experimental and numerical analyzes so that they could be considered in designing a practical and efficient. (Figueiredo, 1998)

In Oliveira (2008) we see specific interaction steel is only possible when both elements work together, allowing the transfer voltage. The mechanisms by which stresses can be transferred from the concrete core to the steel tube are adhesion, and frictional interface roughness.

These mechanisms are generally known as natural grip. The accession act separately from the other two plots, while the roughness and friction depend on the mechanical characteristics of the interface and relate to each other. If the natural adhesion is not sufficient to achieve the necessary shear strength, it is possible to use shear connectors. The behavior of the transfer of shear stresses at the interface between the concrete and steel composite column is based on the force needed to slip, obtained in tests pullout or push-out (OLIVEIRA, 2008).

THE CONTAINMENT OF CONCRETE

In concrete traditional technique, the confinement of the column core is primarily attributable to partial obstruction of the mass expansion of concrete through the space between the vertical reinforcement stirrups and the horizontal (figure 3a).

Moreover, it is known that to increase the compressive strength of all it is important to decrease the vertical space between the stirrups, which are added in an amount which increases the possibility of "fouling" caused by the rock aggregates, causing thereby isolating the lean concrete located between the armature and the outer surface of the pillar (figure 3b), that portion which becomes a mere sealing together subject, therefore, the deterioration caused by the weather.

In Figure 3c we note that these issues are solved by itself when using the technique of CFT, since the whole section is uniformly confined concrete inside the steel casing, which also becomes an efficient protector of external actions, if properly treated by anti-corrosive.

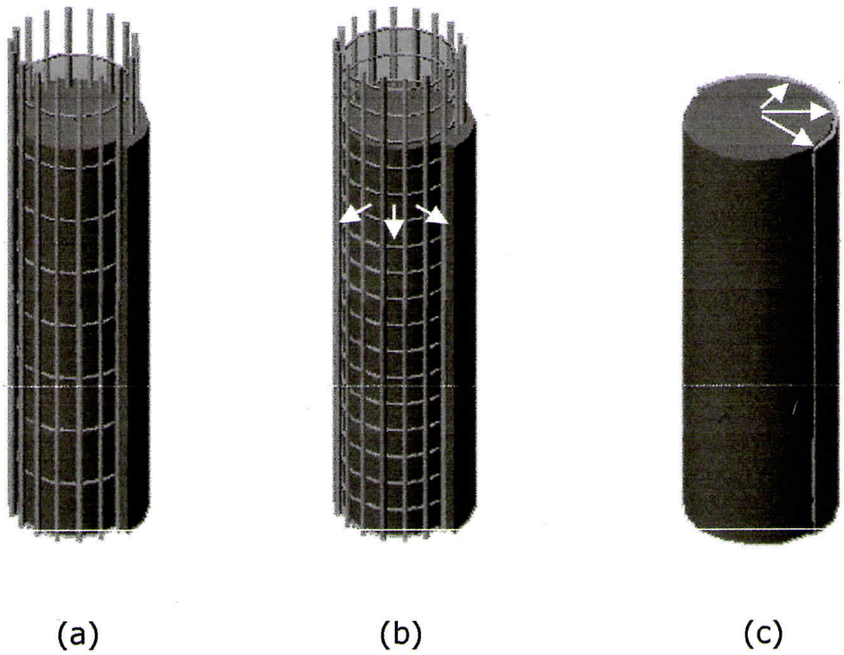

Figure 3 - Comparison between concrete traditional technique and concrete filled steel tube technique

A RETRACTION OF CONCRETE CONFINED

We can define as deformation retraction that occurs in the section of concrete regardless of the action of external factors, whether physical or environmental. This retraction is produced for reasons intrinsic to the very structure of the material, such as dosage or trace of composite behavior of aggregates, cement quality, time of healing, etc.. In the case of CFT, this phenomenon can cause the detachment of the concrete inside wall of the tube which could lead to the assumption in the loss of joint strength. In this respect we have in Figueiredo (1998) ...

However, there is still controversy about the relevance of considering whether or not the effects of retraction on the resistance of the pillar. The studies that claim that these pillars the effect of shrinkage can be neglected is justified in the fact that the pillars are filled in details that minimize the effect of the downturn such as the mode of healing that takes fully protected by a steel tube, preventing the action of wind and sun, and make the cure more slowly. Since UY & DAS (1997), although agreeing that the effects of shrinkage on a pillar will be completed in less than a pillar of concrete due to curing conditions, say there is need for more research to evaluate this parameter and that the retraction will cause significant distortion in columns filled and should be provided in the design, especially for tall buildings. UY & DAS (1997) developed a numerical model to evaluate the effects of shrinkage and creep, considering the construction of each floor as a loading discreet.

CDW RECYCLED AGGREGATE

In Veneziano C.T. et al consistent reasons are cited for the use of recycled material RCD taking into account the intense industrialization, the advent of new technologies, population growth and diversification of consumption of goods and services, raw materials, that have become scarce, and the residues that have become a serious urban problems requiring complex management. In this context, one of the most responsible for the consumption of natural resources extracted and the generation and disposal of waste is the construction industry. Currently, finding good natural aggregates close to urban areas is increasingly difficult. Furthermore, the distances between sources and locations of new buildings are rising. Problems with the management of waste generated, the shortage of disposal areas, and urban sanitation, among others, are points that should also be considered in the analysis of environmental impact. All these factors lead to the search for alternatives to minimize the impact generated by the construction industry. Recycling is undoubtedly the best alternative to reduce the impact that the environment can suffer from material consumption and waste generation.

The IBGE - Brussels Institut pour la Gestion de l'Environnement in its technical report on construction relarório copies devotes extensive chapter on the use of pellets from recycling RCD. Since the road paving application, manufacture of plates or bricks coating structural by its inclusion in the mixture to aggregate the concrete. In the figures below we see some cases of successful use of such waste.

The use of recycled granulates offers substantial advantages with regard to ease of production and screening, which may take place both at the sampling and the deposition or application, thus generating a considerable savings in the operation of transport, which does not happen with use of natural aggregate.

Figure 4 shows the typical cycle from the granulation of the aggregate application.

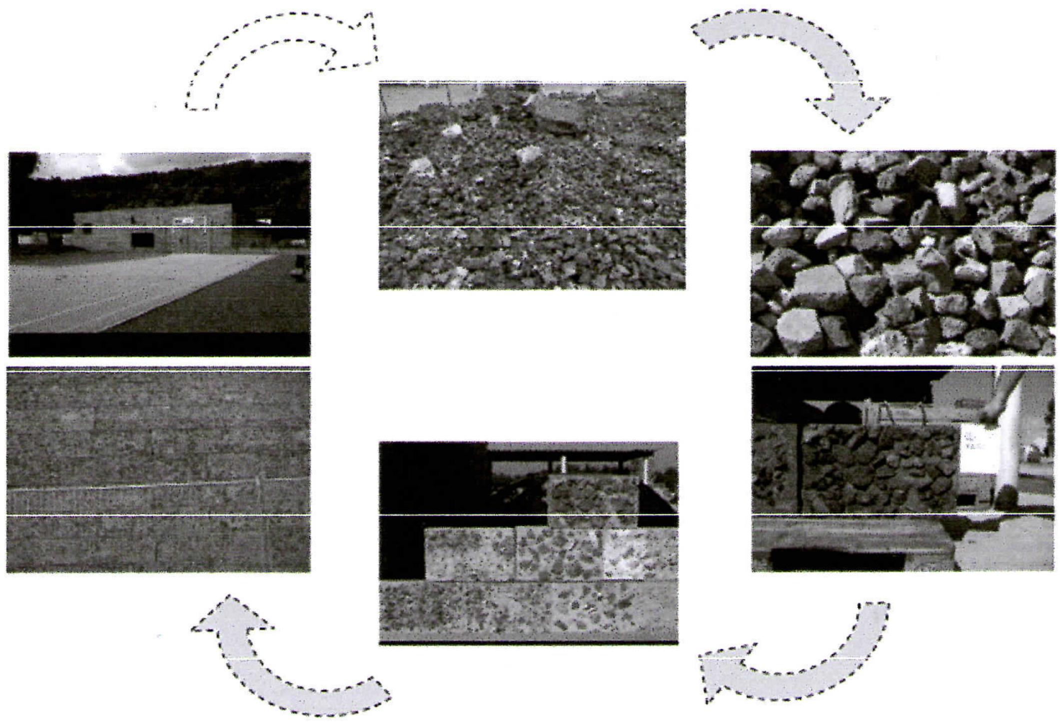

Figure 4 - Typical cycle from the granulation of the aggregate application

In Venetian CT et al, reports a test of compressive strength in specimens with RCD granules showing the possibility of employment in the manufacturing of structural concrete even with some caveats.

It collected a large amount of residue, which underwent a manual separation and classification of gray (predominantly cement-based waste) and red (predominantly ceramic waste). The two parts have undergone determination tests particle size, absorption, density and unit. The final phase was formed by making concrete with different proportions of coarse aggregate, varying the composition of recycled aggregates RCD gray, red and conventional aggregate.

RESULTS

The tests performed showed that the compressive strength will vary as the composition of the coarse aggregates, having smaller resistance when the ratio is larger aggregates. It was proven that the samples had aggregates of gray RCD reach higher strength than those from RCD red. Some samples did not meet with ceramic waste strength greater than 20MPa, can not be considered concrete structural function. As expected, no specific resistance achieved by conventional concrete reached 37.8 MPa.

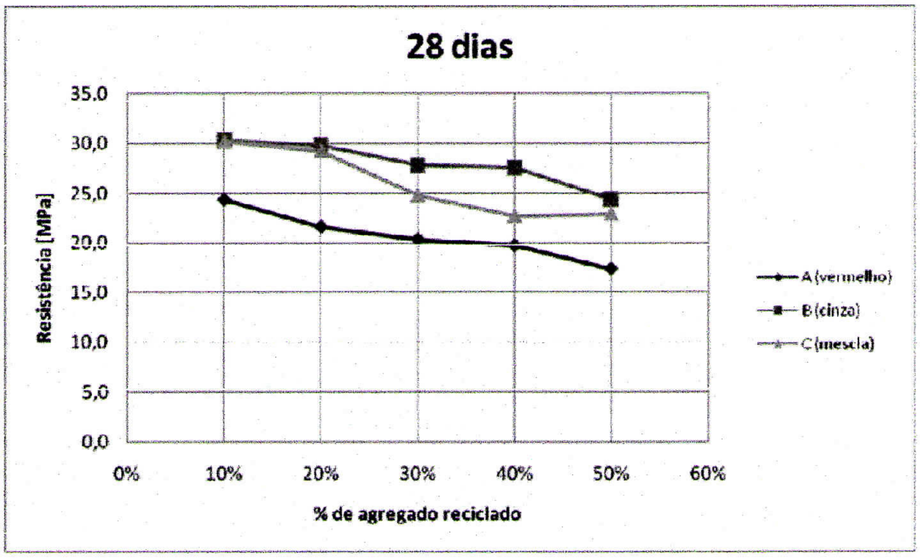

Table 1 - Resistance of concrete and percentage of recycled aggregate

COMPLETION OF TESTS

The work proved the technical feasibility of producing concrete with structural function using recycled coarse aggregate, from RCD, to a certain extent. Thus, the use of construction and demolition waste as aggregates for concrete production is an interesting way to reduce the exploitation of natural resources, increasingly scarce, and allocate the construction waste, becoming more abundant. This practice will minimize the problems with the management of municipal solid waste, since there will be an increase in useful life of landfills, reducing the points of illegal disposal and reducing costs of waste management (VENETIAN et al.).

FIRE RESISTANCE OF CFT

The fire resistance Santos (2009) gives us an overview and illustration of the behavior of CFT: the elements of concrete when subjected to high temperatures cause the occurrence of fragments characterizing the phenomenon called "spalling." The CFT, significantly reduce this effect due to the confinement imposed by the steel tube. Note also reduced the rate of heating of the set assigned to the low thermal conductivity of the concrete.

Currently, investigations concerning structures in fire grow significantly on the world stage. This fact is justified by the need to evaluate the performance of these structures when they are subjected to thermal action. The gradual increase in temperature causes changes in the mechanical properties of materials, allowing it reduced strength and stiffness, the structure can lead to premature

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failure.In the case of composite steel columns filled with concrete, when subjected to thermal action, besides presenting very satisfactory structural behavior, reduces or even prevents the chipping phenomenon, called "spalling" (present in concrete elements subjected to high temperatures), due to the effect of the confinement imposed by the concrete steel tube.

As described in Han (2003), steel tube begins to expand axially in the early stage of heating, starting to receive most of the applied load, causing the compressive stress in the concrete core decreases. Subsequently, with increasing temperature, the steel shall be deformed locally and the load is also to be resisted by the concrete. In a final stage of the steel, axially, no longer supports the load applied, however, stillmobilizes restriction radial deformation of the concrete core to the instant of rupture of the composite element as a whole.

According to Ding and Wang (2008), most researchers assumed as simplifying assumption, during exposure to fire, the perfect contact at the interface between steel and concrete in composite columns filled. However, this latter reference highlights the fact that the expansion of the steel is greater than that of concrete, requiring a detachment in contact giving rise to the existence of a "slack" (air gap) between them, a phenomenon that should be taken into account experimental and numerical analyzes. However, the same reference points out that this consideration should be further investigated in future in order that occur cases where the timefire resistance grows due to the failure.In the case of composite steel columns filled with concrete, when subjected to thermal action, besides presenting very satisfactory structural behavior, reduces or even prevents the chipping phenomenon, called "spalling" (present in concrete elements subjected to high temperatures), due to the effect of the confinement imposed by the concrete steel tube.

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