RECYCLED MATERIALS IN CIVIL ENGINEERING

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ABSTRACT

We never educate directly, but indirectly by means of the environment. Whether we permit chance environments to do the work, or whether we design environments for the purpose makes a great difference. — John Dewey

Every year human settlements produce 1.3 billion tones worth of solid waste products. The scope is that we could and should putting this together to good to use, cheap and durable and Green Building Materials. Recycling of waste construction materials saves natural resources, saves energy, reduces solid waste, reduces air and water pollutants and reduces greenhouse gases. The construction industry can start being aware of and take advantage of the benefits of using waste and recycled materials. Studies have investigated the use of acceptable waste, recycled and reusable materials and methods. The use of swine manure, animal fat ,silica fume, roofing shingles, empty palm fruit brunch, citrus peels, cement kiln dust, fly ash, foundry sand, slag, glass, plastic ,carpet, tire scraps, asphalt pavement and concrete aggregate in construction is becoming increasingly popular due to the shortage and increasing cost of raw materials.

In this study a questionnaire survey targeting experts from construction industry was conducted in order to investigate the current practices of the uses of waste and recycled materials in the construction industry. This study presents an initial understanding of the current strengths and weakness of the practice intended to support construction industry in developing effective policies regarding uses of waste and recycled materials as construction materials.

KEYWORDS: (*Solid Waste Products, Recycling, Questionnaire Survey,*)

1. INTRODUCTION

Several issues exist regarding reducing waste. A key environmental issue is waste incinerators, furnaces for burning trash, garbage's and ashes. These incinerators produce 210 different dioxin compounds plus mercury, cadmium, nitrous oxide, hydrogen chloride, sulfuric acid and fluorides. Produced also in incinerators is particulate matter that is small enough to remain permanently in the lungs. Additionally, waste incinerators generate more co_2 emissions than coal, oil, or natural gas- fueled power plants. For years, scientist and researchers have been searching for possible solution to environmental concerns of waste production and pollution. Many have found that replacing raw materials with recycled materials reduces our dependency on raw materials in the construction industry. The BAI (Building Association of India) which produces 300 tons of construction waste per year . It reveals that a significant amount of material wastage can be reduced by the adoption of pre fabrication and the rates of reuse and recycled waste materials are relatively higher in projects that adopt prefabrication. In addition to a reduction of construction waste generation and it was identified and discussed over advantages survey one issue companies felt need addressing is the creation of a separation process on site process oppose to one accumulation of all waste in one pile. A solution to this problem would be planning recycling in to the pre construction plans in advance. Integrated Solid waste Management (ISWM) is the selection and application of suitable techniques, technology management programs to achieve specific of applying prefabrication and in the construction activities. This include enhance integrity on the building design and the construction, reduction in unskilled workers ,reduce construction cost, fix the design at the early stage of design, better supervision, promotes safer and more organized construction site, and improve environmental performance through waste minimization. Further, from the result of

waste management objectives and Goals Malakahmad .et.al (2010) and his Colleagues suggested the implementation of ISWM systems as a tool for sustainable development. They concluded that one key element of ISWM is solid waste separation, which contributes to a successful recycling program.

The researchers developed several green material technology programs, which maintain or improve current practices in construction engineering and ensures green products or methods arising from these programs would be cost effective and would confer benefits on society, the economy and the environment. In order to obtain knowledge of the most advanced use of waste and recycled materials. For instance James et.al (2011) researched the potential use of recycled concrete aggregate (RCA) and fly ash (FA) in concrete pavement. The recycled concrete came from a demolished local site. Their research revealed that using RCA up to 25% and FA up to 15% will not have a significant difference in strength compared with concrete containing virgin aggregate. Thus using RCA and FA in concrete pavement may promote economical and environmental benefit. Hamoush et,al (2011) investigated a new improved engineered gladding stone for better toughness, ductility, durability, and thermal resistance in their research, the back layer of the stone utilized recycled crumb rubber, which provides a combined solution for energy saving and environmental concerns. The results of adding crumb rubber showed a reduction in the material unit weight, enhanced ductility and toughness and improved thermal resistance. The stones properties such as compressive strength, thermal resistance and water conductivity, durability, impact resistance and water absorption were experimentally measured and compared with natural stone specimens. Kaosol (2010) conducted research on reusing the water treatment sludge from a water treatment plant to make hollow concrete blocks. His objectives were to increase the value of the water treatment sludge from a water treatment plant and to make a sustainable and profitable disposal alternative for the water treatment sludge. Findings showed that the production of the hollow concrete blocks be a profitable disposal alternative in the future.

This study presents a results from a questionnaire survey conducted to find out what recycled and waste materials are currently being used in the construction industry and areas were construction related companies need to be informed more to increase the potential use of such materials. The focus was on applicable waste and recycling materials within four sectors, namely composite waste, industrial sector waste, municipal sector waste and transportation sector waste. Each sector includes subsections of recyclable materials in relation to the construction industry the transportation sector waste that can be used as beneficial recycled materials including tire rubber, reclaimed asphalt and recycled concrete aggregate. The municipal sector waste contains beneficial materials for the construction industry including roofing shingles, glass, plastic and carpet. The industrial sector waste contains beneficial materials including cement kiln dust, foundry sand, fly ash silica fume and slag. The composite waste sector includes swine manure, animal fat, empty palm fruit bunch, Citrus peels, and sewage sludge

The main objectives of this study are to investigate the effective use of recycled and waste materials in various construction applications. Goals and Objectives include:

1) Review of studies of recycled materials in construction application (2) survey of current practices of uses of waste and recycled materials in the construction
(3) Connecting researchers and industry with an overview of recycled materials are available for different applications and
(4) Better Documentations for green infrastructures benefits

2. MATERIALS AND METHODS

2.1 Tire Rubber

An estimated number of one billion scrap tires have been disposed of in huge piles across our country. An additional 200 million tires unaccounted for discarded yearly. Whole tires have been used in artificial reefs, break waters, dock bumpers, soil erosion control mats and play ground equipment.

Several studies have shown that the tire waste can be successfully used in concrete, grass turf, asphalt mix, embankments, stone cladding, flow able fill and clay composite.

2.2 Reclaimed Asphalt Pavement

The transportation sector has used reclaimed asphalt pavement (RAP) for many years.RAP is used to backfill pavement edges, rework base and base course. According to the world business council for sustainable development, manufactures around the world produce more than 25 billion tons of concrete yearly.

2.3 Recycled Concrete Aggregate

BOI projected an increase in aggregates to over 2.5 billion tons per year. Crushed aggregate has been used as base course or granular base in highway construction. Its primary function is to increase the load capacity of the pavement and to distribute the applied load to avoid damage to the sub grade.

2.4 Roofing Shingles

Each year India generates approximately 11 million tons of asphalt roofing shingle scrap use of recycled asphalt shingles (both manufacture's and tear offs) increased from 702,000 tons to 1.10 million tons from 2009 to 2010 which represents a 57% increase. Assuming conservative asphalt content of 20% of for shingles this represents 234,000 tons (1.5million barrels) of asphalt binder conserved. Roofing shingles are made from a fiber glass or organic backing, asphalt cement, sand-like aggregate and mineral fillers such as dolomite, limestone and silica. Beneficial applications include, but not limited to, hot mix asphalt (HMA), cold patch mix asphalt, aggregate substitute, base course, mineral filler and granular base stabilizer. Benefits of using roofing shingles include lower disposal costs for single scraps manufacture reduced cost reduce in the production of HMA, improved the rutting resistance of the mixtures considerably due to combination of the fibers and harder asphalt and improved resistance to pavement cracking.

2.5 Glass

Indians generated 1.5 million tons of glass in the municipal solid waste management (MSW) stream in (2010). Glass is composed of silica or sand and contains some amounts of limestone used to and soda ash produce uniform quality and color. According to the Association of cities and Regions for Recycling (ACRR) , people around the world send 1.5 million tons of glass to landfills each year .Glass that end up in the landfill won't break down for over a million years. Glass cullet creates workability problems in a concrete mix and the likelihood of alkali –silica reaction. Beneficial uses are in the secondary applications, such as in the manufacture of fiber glass insulation, roadbed aggregate, driving safety reflective beads and decorative tile.

2.6 Plastic

In 2010 plastic waste generated approximately 31 million tons, representing 12.4% of total municipal solid waste .Uses of recycled plastic in the construction industry include plastic strips to add soil embankments, which has positive results of increasing the measured strength in reinforcement of soils. HMA mixture has a mixture has a higher stability, reduced pavement deformation; increase fatigue resistance and provide better adhesion between the asphalt and the aggregate. Grinded polyethylene to provide better coating or attached easily to the aggregate as the surface area of the polymer increase.

2.7 Carpet

Carpet waste diverted from landfills was 338 million pounds. 271 million pounds were recycled, 3 million pounds used for alternative fuel and 23 million pounds for cement kilns. Old carpet is being recycled and used in composite lumber (both decking and sheets), tile backer board, roofing shingles, rail road ties, automotive parts ,carpet cushions and stepping stones. A study by Wang et .al (2000) provided that by adding fibers to concrete, both toughness and tensile properties increased. Other benefits in adding carpet fiber to concrete include reduction of shrinkage, improved fatigue strength, wear resistance and durability.

2.8 Cement Kiln Dust

CKD (by product of manufacturing Portland cement) is fine grained, highly alkaline waste, removed from the cement kiln exhaust gas by air pollution control devices. Uses of CKD may include : soil stabilization ,waste treatment, cement replacement and asphalt pavement.CKD is perfect as soil stabilizer improving soil stabilizer improving soil strength and minimizing work and cost. CKD is a quality adsorbent and natural alkaline that makes it an effective waste treatment.CKD added to asphalt binder produces low ductile mastic asphalt and provides stripping resistance for the pavement.

2.9 Foundry Sand

It is a by-product of ferrous and non-ferrous metal casting. It is high quality silica sand with uniform physical characteristics. Foundry facilities operate by purchasing high quality silica sand to make casting molds and reuse the sand numerous times within the foundry. Beneficial reuse of foundry sand continues to become more accepted practice as more end-users are introduced in to the concept. Beneficial application of foundry sand include aggregate replacement in asphalt mixtures, Portland cement concrete, source material for Portland cement, sand used in masonry mortar mixes, embankments, retaining walls ,sub base ,flow able fills ,barrier layer and HMA mixtures.

2.10 Silica Fume

The environmental concerns necessitated the collection and land filing of silica fume to be mandatory. Perhaps the most important use of this material is as mineral admixture in concrete. Silica fume is added to Portland cement concrete to improve its properties, in particular its compressive strength, bond strength, and abrasion resistance. These improvements stem from both the mechanical improvements resulting from addition of a very fine powder to the cement paste mix as well as from the pozzolanic reactions between the silica fume and free calcium hydroxide in the paste.

2.11 Fly Ash

Fly ash (FA) is the by-product of coal combustion in power generation. Coal provides more than half of the Nation's electricity and continues to be the fuel of choice for generating power. Fly ash is a powdery substance laced with heavy metals such as arsenic, mercury and lead.fly ash can be alternative to another industrial resource, process or application. These process and application include, but are not limited to cement and concrete products, structural fill and cover material, roadway and pavement utilization. Infiltration barrier and underground void filling. It can be used as partial of cement because of its beneficial effects. Such as lower water demand for similar workability, reduced bleeding, reduce cracking at early stage and lower evolution of heat. High lime fly-ash has permitted normal replacements of 25-40 and up to 75% of cement in concrete materials for parking lots, driveways and roads.

2.12 Slag

Slag is a co-product of the iron and steel making process. Once scorned as useless, it is now recognized as a valuable material with many uses in agriculture, environmental applications and in construction industry. Air cooled course aggregate is used in concrete, asphalt mixes, fill materials in embankments, road base material and as a treatment for the improvement of soils. Ground granulated blast furnace slag (GGBFS) has a positive effect on the flexural and compressive strength of concrete. Expanded slag has low density allowing for good mechanical binding with hydraulic cement paste. Bulk density, particle size, porosity, water holding capacity and surface area makes it suitable for use as an adsorbent.

2.13 swine manure

The environmental effects of swine manure storage systems and application methods are concern, mainly with respect to surface water, ground water and air quality as affected by odors and gaseous emissions from large scale swine production operation process. The swine manure is converted in to bio-binder, replacing petroleum adhesives with bio-degradable adhesives. The viscosity of bio-modified binder wettability which in turn may improve mixture

durability. Decrease in stiffness and increase in relaxation capability of binder implies improvement in low temperature properties and reduction in low temperature cracking. By adding 2% bio-binder one can maintain high temperature grade of binder.

2.14 Animal Fat

Animal fat has been used in the construction industry since roman times. It is also referred as tall oil.

2.15 Citrus Peels

During the seasons of citrus juice production generates 10.6 million metric tons of waste. Research shows that the citrus peel can be an alternative to commercial activated carbon that is high in capital and regeneration costs, which is the preferred adsorbent. For removal of methylene blue (MB). MB is a dye that comes from waste water from textile industries and can cause severe environmental pollution if emitted to the environment without proper treatment.

2.16 Sewage Sludge

Course solids and bio solids accumulated in a waste water treatment process must be treated and disposed of in a safe and effective manner –creating sewage sludge. This material may be inadvertently contaminated with toxin organic and inorganic compounds. However, sludge ash has been investigated in the production of concrete. Results of several studies have indicated the benefits of using sewage slag ash in concrete as compressive strength, freeze –thaw resistance and good hardening properties. Sewage sludge ash may be used as a mineral filler substitute or as a portion of the fine aggregate in hot mix asphalt paving.

2.17 The survey

Sustainable green infrastructure is growing concept of saving energy, natural resources and cost, as well as in the solution to environmental concerns involving waste. In order to accomplish the growing industry of green infrastructure, the end users including contractors, engineers and suppliers have to b informed about what recycled/waste materials are available to use in the construction industry. To find out what end users are aware of recycled and waste materials and who are actually using them, companies have to be approached and questioned. The survey intends to reveal the barriers or issues behind not using recycled materials in the construction industry. Results of the survey presents an initial understanding of the current strengths and weakness of the practice intended to support construction industry in developing effective policies regarding uses of waste and recycled materials as construction materials.

2.18 Methodology

A questionnaire survey was conducted through phone calls, visits, 1) If the company uses or sells any waste or recycled materials for construction application,2) Is the surveyor aware of other recycled materials that are being used in construction applications,3) Are there any recycled materials that are not recommended for use in the construction industry and 4) If not using such materials, what are the barriers behind not using recycled materials in their work. All the questions ended with a yes or no using the material. The survey consisted of a list of recycled and waste materials including; cement kiln dust (CKD), fly ash, foundry sand, slag, glass, plastic, carpet, tire rubber, recycled asphalt, recycled concrete, gypsum, silica fume, swine manure, animal fat, soy bean, roofing shingles, citrus peels, sewage sludge, date and palm tree and a place to add additional recycled materials being used in the construction industry. The last question was include to record any additional contact or references to question for more information on the topic.

3. RESULTS

The survey was complied of 30 participants from 6 companies. The companies survey consist of Contractors, Engineers, Architects and suppliers of concrete, asphalt, landfills, scrap yards, Steel Manufactures, Drilling ,Demolition and recycling companies.

Figure 1 shows responses of the surveyed companies on the most recycled materials .From this sample of companies, the most common recycled materials was recycled concrete at 15% followed by recycled asphalt and wood, with 12 and 8 % respectively. Several percent of the companies did not use recycled

materials at all. **Figure 2** shows the percentage of the most commonly recycled materials used in the concrete. Recycled concrete was found to be the most popular at 54%, the cost is low compared to purchasing natural stones and aggregate and its availability is high because of demolition of older buildings and highways. It should be noted that in order for concrete to be recycled and reused as a aggregate, it must be cleaned and washed for DOT approval. Fly ash was very popular, with 20% of companies using in it concrete. Companies noted that FA is a great substitute for cement and it is cost effective. Some mentioned that slag (12%) and silica fume (9%) for special projects, varying use according to the engineer from job to job bases. Tire rubber (4%) was found be used in concrete including concrete barrier applications. Some companies are using cement kiln dust and glass in their concrete. Companies using recycled asphalt (57%), grinded the old asphalt in to course and fine course, then applied it to the new asphalt paving process. **Figure 3** shows the most commonly recycled materials in asphalt. There is also high percentage of recycling roofing shingles (36%) that asphalt companies use. Of all the companies surveyed ,7% explained that they are not using recycled materials due to cost, lack of education regarding certain materials, limited to the special cases, environmental quality of the product, contamination ,permits, separation process, lack of market to buy the material, no equipment, storage ,sent to scrap yards and landfills and availability. **Figure 4** shows the percent of reasons why companies are not using recycled materials.

The companies surveyed, felt that cost made up 22% of the reasons why they do not use certain recycled materials in the construction industry. The cost outweighs the benefits for using certain recycled materials. Some processes are expensive to operate including glass and the recycling tire scraps.

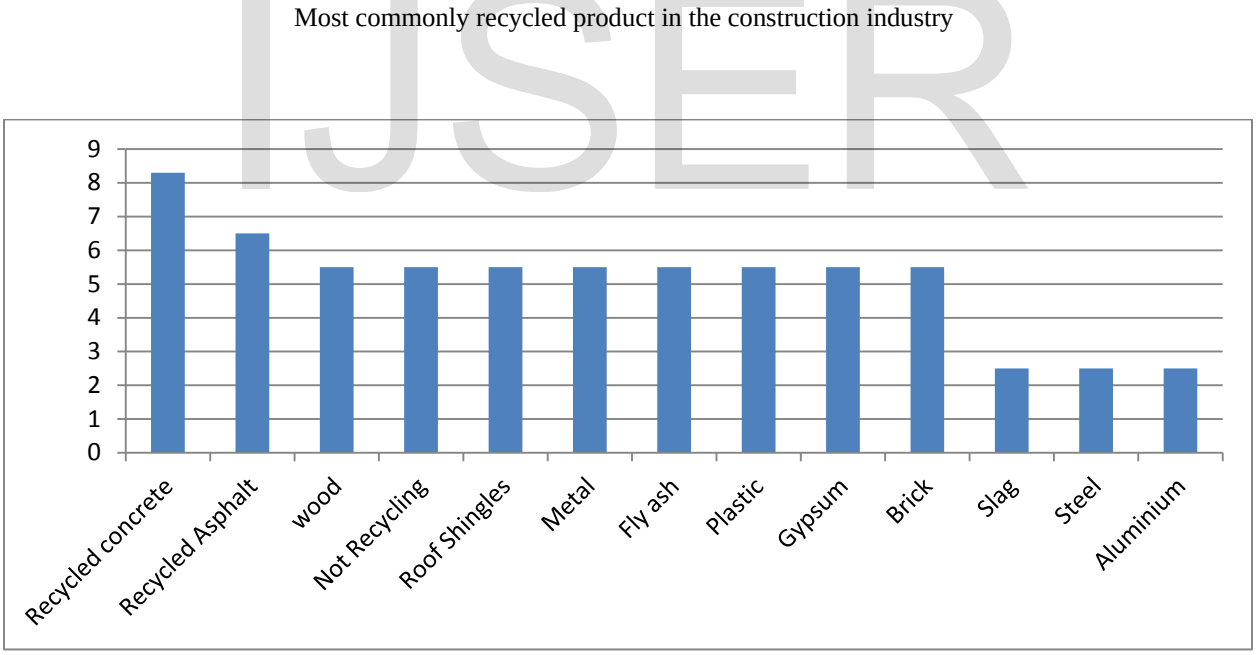

Figure 1.Most commonly recycled product in the construction industry

Most commonly recycled material used in concrete

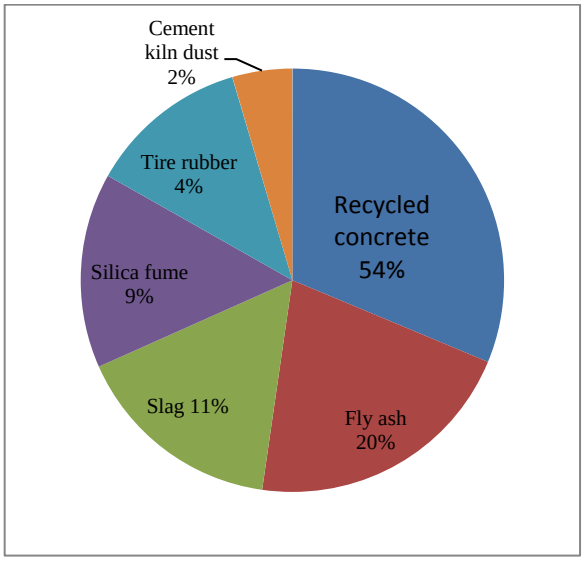

Figure 2 Most commonly recycled material used in concrete

Most commonly used recycled material used in asphalt paving

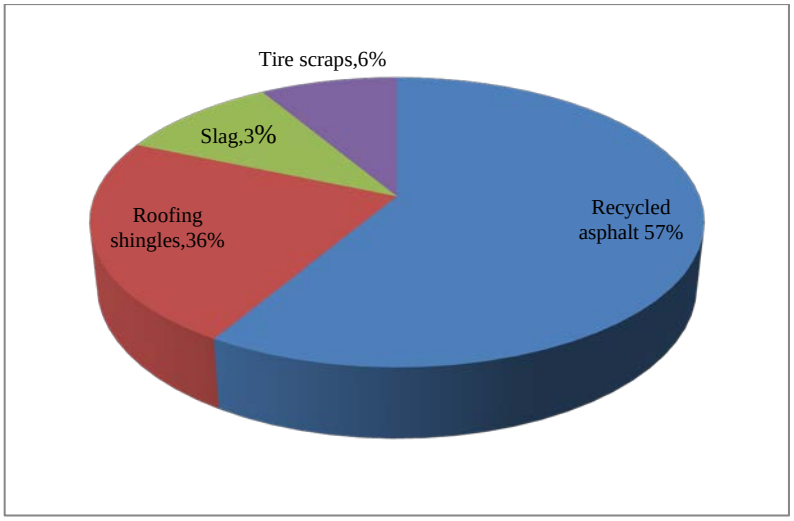

Figure 3. Most commonly used recycled material used in asphalt paving

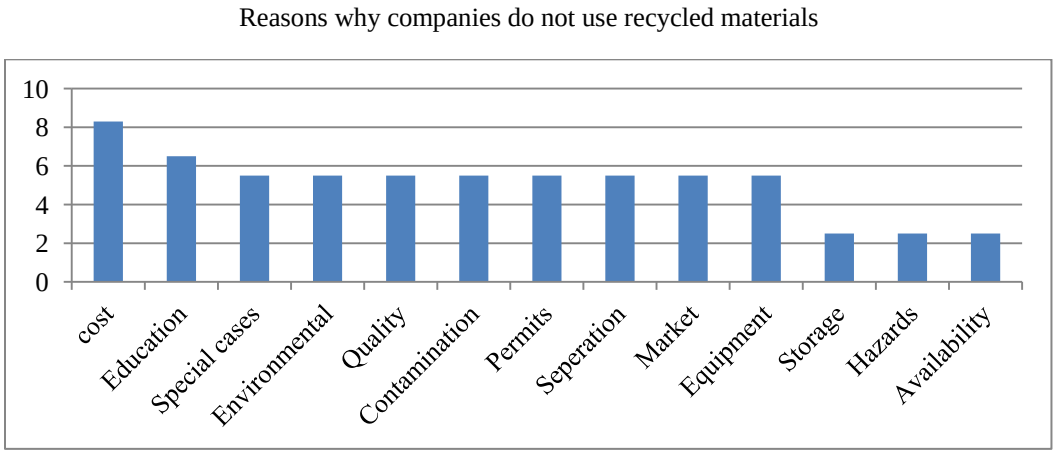

Figure 4 Reasons why companies do not use recycled materials

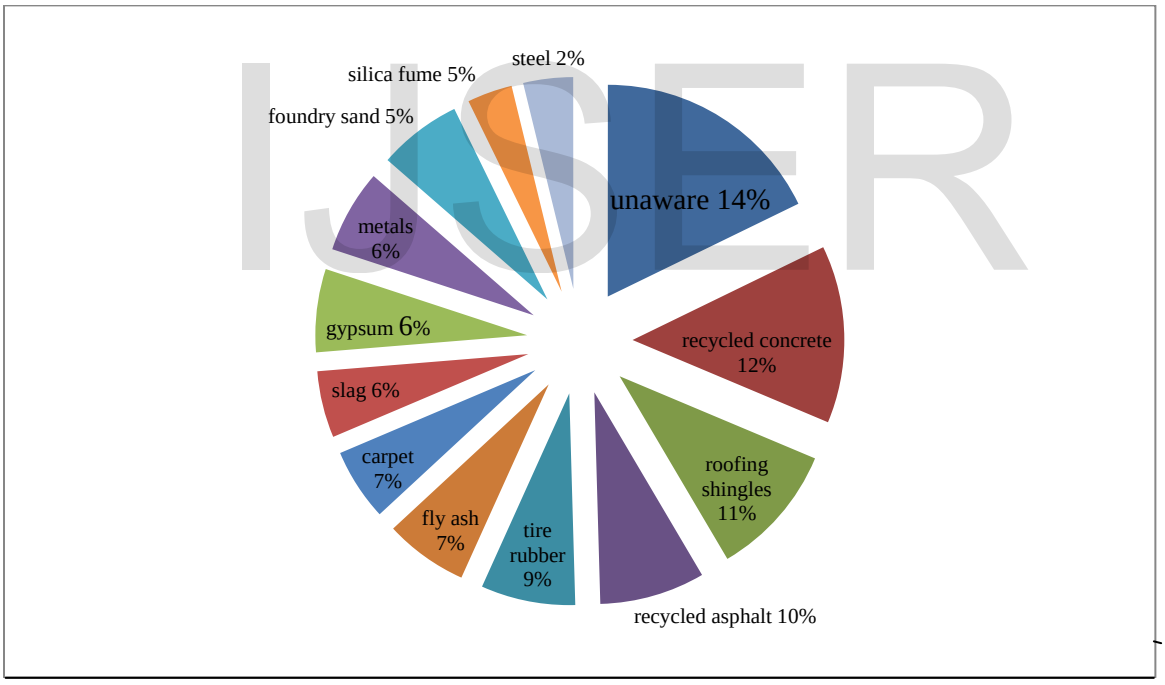

Figure 5 Awareness of recycled materials for construction applications

Environmental hazards include fly ash which contains traces of arsenic and mercury, roofing shingles contains asbestos and molding issues in some gypsum. Quality of end products represents 11% of the reasons why recycles materials were not utilized. Contamination, which makes 85 of the reasons, was another issue of not using recycled materials due to the reduced performance of the applications. The need to have permit for certain waste materials, high cost of the separation process and lack of marketing of the recycled material each represents 7% of why companies choose not to use recycled materials. Recycled materials such as date and oil palm, sewage sludge, citrus peels, soy bean, animal fat, polyester lumber, rice husk and swine manure were among other materials that are poorly documented. In order to accelerate the growth of the use of recycled materials in the construction industry, surveyed companies suggested that need for more research, analysis and data before the use in construction application.

When companies asked about the benefits of using recycled materials, reducing landfill waste was number one at 38% followed by quality at 33% then reduced cost at 27% .they attribute the quality to some recycled materials that can improve strength such as silica fume which can be used to produce high strength concrete.

4. DISCUSSION

4.1 Statistical Analysis

As a fore mentioned 30 participants from 6 different field of companies participated in this study.

Table 1 and **Table 2** summarize the stasticial findings of the survey. **Table 1** was generated from the responses of companies that use recycled materials in the different construction applications, while **Table 2,** and was generated from the responses of companies that do not use recycled materials in their products or applications.

Table 1. Percent use of recycled material

Materials %	Materials %
Recycled concrete 15.0	Roofing shingles 7.0
Wood 8.0	Fly ash 5.8
Metal 6.0	Brick 5.0
Gypsum 5.8	Steel 3.0
Slag 3.0	Glass 1.0
Aluminum 2.0	Tire rubber 1.0
Silica fume 2.0	Foundry sand 1.0
Clink dust 2.0	Soy bean 2.0
Carpet 2.0	Animal fat 0.0
Swine manure 0.0	Sewage sludge 1.0
Citrus peel 0.0	Recycled asphalt 12.0

Table 2 Reasons for not using recycled concrete

Reasons %	Reasons %
Cost 22	Marketing 7
Lack of education 13	Equipment 4
Hazards 11	Storage 4
Quality of end product 11	Availability 4
Contamination 8	Permits 7

5. CONCLUSION

Review of several studies suggested that the use of recycled materials has positive impact through different aspects .This includes the benefits in enhancing sustainability of the construction industry while reducing cost, providing solutions to environmental pollution and reducing the need for natural resources. In This study, a questionnaire survey was conducted to find out the current practices in using waste and recycled materials in the construction industry. Results indicated that some companies were not aware of the availability, quality of the materials performance, cost savings, or any other benefits including environmental benefits. It is thus recommended to create better documentation for

green infrastructure, connecting researches and industry with an overview of what recycled materials are available for different construction applications. Companies need to be innovative in their use of recycled materials and reduce their dependency on raw materials. Also more data and better documentations are needed to encourage the use of waste and recycled materials in the construction industry.

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