A Brief Introduction of concrete Requirement with its Environmental Impacts

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ABSTRACT

Concrete is the 2nd largest used material after water on the earth. With the increase of necessity of concrete day by day world also needs concrete as environmental friendly material with saving of non renewable resources of energy, reduce CO₂ emission, and provide aesthetically pleasing and healthy surroundings. Concrete fulfills all these requirements of present scenario as well as for future. The biggest benefit of using concrete with waste product is in minimizing the waste materials. Most of the essential research has been done to enable concrete to fill this role with environmental safety precaution. This paper presents about the current active researches taking place around the world on study of various environmental aspects of concrete. With better utilization and manufacturing of cement as well as concrete, we can reduce the effects of CO₂ emission, nitrous oxide emission, particulate air emission, visual pollution, traffic congestion, noise pollution, water pollution, adverse health effects. Concrete became the most widely used construction material in the world for a very good reason - it benefits mankind more effectively than any other building material. The environmental benefits of concrete can be taken as low maintenance, low energy consumption, desirable engineering properties, Sink for liquid combustible hazardous waste, Sink for silica rich industrial wastes, Thermal mass saves heating and cooling cost, green aggregates, Concrete can be recycled.

Keywords- Cement, Renewable Resources, Green Concrete, Recycled concrete, silica

1. INTRODUCTION

The environmental problems with concrete will be discussed next in order of decreasing importance according to perception of the problems.

CO₂ emissions
The most serious problem with our industry is that it is a major CO₂ emitter causing global warming. With every ton of cement produced, almost a ton of CO₂ is emitted. About 0.5 tons comes from the decomposition of the limestone and the balance is generated by the power plant supplying the electricity to turn the kiln and ball mills to grind the cement plus the fuel burned to fire the kiln. All other generation such as operating ready mix trucks adds only a minor amount to the CO₂ emissions. In terms of conventional concrete mixtures (i.e. not using fly ash, slag or silica fume), about 480 kg of CO₂ is emitted per cubic metre of concrete or 20 kg of CO₂ per 100 kg of concrete produced. All of this amounts to about 7% of the total CO₂ generated worldwide. Enhanced efficiency is not likely to change this but replacement of some of the cement by a supplementary cementing material not associated with CO₂ emission can substantially reduce these emissions.

Nitrous oxide emissions
Nitrous oxide emissions come from burning gasoline, coal or other fossil fuels. Ozone is formed when nitrogen oxides and volatile organic compounds mix in sunlight. The volatile organic compounds come from sources ranging from industrial solvents to volatile resins in trees. Ozone near the ground can cause a number of health problems such as asthma attack, sore throat, coughing and other health difficulties. In addition, nitrous oxide, carbon dioxide and methane are the most important greenhouse gases.

Reduction in nitrous oxides is normally achieved by reducing the burning temperature or by injecting ammonia compounds into the high temperature exhaust stream. This seems like a good idea but when these actions are taken to reduce the NOx in coal fired electric power generating stations, it adversely affects the quality of the fly ash produced. The fly ash then needs to be treated to remove the unburnt coal and ammonia gas before it can be used in concrete mixtures and several
plants doing this are in operation. Several research programs are currently underway to find out how best to beneficiate fly ash to correct this problem.

**Particulate air emissions**

Particulate emissions from the exhaust gas range from 0.3 to 1.0 kg/tone and much of this kiln dust is collected in fabric filter bag houses and then reintroduced into the kiln feed. It is normally very rich in sodium and potassium which have vaporization temperatures of only 883°C and 774°C respectively. In the past, before there was a concerted effort to capture the particulate emission, the sodium and potassium plume from cement plant chimneys settled over the countryside where it helped to combat acid rain. Now it is mainly carried out in the clinker stream where it creates problems with alkali aggregate reaction.

**Visual pollution**

Visual pollution resulting from quarries used to gain raw material for cement production or for obtaining sand and gravel can be sculptured to meet the natural topography and when abandoned can be planted with vegetation that can make them blend in with the natural surroundings. Unfortunately most quarries have a very long life and any attempt to sculpture the topography for a visual effect is counter-productive to the efficiency of the quarrying process. The most effective end use might be for educational or recreation purposes with special attention being paid to public safety.

**Traffic congestion**

Traffic congestion in the delivery of the cement and of ready-mix concrete is being mitigated by using large energy-efficient delivery vehicles. With appropriate attention to noise suppression and dust control at ready-mix plants there is a tendency to tolerate the placing of the ready-mix plant close to where concrete is needed thereby reducing traffic congestion.

**Noise pollution**

Noise pollution is not normally a public concern as the cement plant is usually placed at a distance from habitation. The ready-mix plant, if it wishes to be located near to its customers must be greatly concerned about noise pollution. At the construction site the use of super plasticizers to produce high slump concrete that requires a minimum of vibration has greatly reduced the problem of on-site noise.

**Adverse health effects**

Currently the health of employees is being adversely affected by the increased chromium content of the cement. The increased chromium content in the cement is mostly derived from the burning of waste products. The only solution seems to be to prevent contact of fresh concrete with human flesh and most containers of cement carry such a warning.

**Water pollution**

On average each ready mix truck returns about one half cubic metre of cement per day. After this concrete is discharged there is still about 300 kg of solids (cement, sand and stone) that is washed out with about 1000 litres of water. In the past the returned concrete and the solids were dumped in a pit at the job site or at the plant. Considering that this represents 2 to 4% of the total concrete produced, it is now considered too valuable to waste and can be recycled or reclaimed as sand and gravel. To reclaim the sand and gravel a “reclaimer” is used. It involves adding water to the returned concrete and then agitating it followed by wet screening to obtain the sand and gravel.

Also, the cement-water slurry from the reclaimer, the wash out water, water to clean the outside of the truck, plus any stormwater in the past usually was directed into somewhat inefficient settling basins and then into a local water course. Recent developments have enabled the concrete retained and any concrete clinging to the inside of the truck drum plus any wash out water to be stabilized overnight or over the weekend by the addition of a hydration stabilizing admixture. This stabilized concrete with an accelerating admixture is used to make up part of the proportions for the next load. In this way there is essentially no water pollution.

### 2. ENVIRONMENTAL BENEFITS OF CONCRETE

Concrete became the most widely used construction material in the world for a very good reason - it benefits mankind more effectively than any other building material. In decreasing order of importance, the environmental benefits of concrete will be discussed next.

**Low maintenance**
Low maintenance is the hallmark of concrete when it is made properly. Some of the first concrete made in 1847 with Joseph Aspdin’s cement was still in good condition in 1983. The concrete was made with a low water to cement ratio and was well compacted. The conclusion from a study of a piece of concrete taken from a boundary wall built by Joseph’s son is that it “is possible to make concrete of several hundred years’ durability”. In the 1930s lack of freezing and thawing resistance presented a problem which was solved with an air entraining agent being added to the concrete mixture. In the 1970s change in cement manufacturing resulted in an increased alkali content which brought on deterioration from alkali-aggregate reaction. This problem has been overcome by developing reliable tests to identify and reject unsuitable aggregates and to limit the alkali content of the cement to manageable levels. In spite of these temporary setbacks concrete is the material of choice to resist severe exposure conditions.

**Low energy consumption**

The raw material to make both the cement and concrete is generally evenly distributed around the world so that transportation is not normally a significant consideration. Also the technology to make cement and concrete is in many ways similar to the technology used by the mining industry and the advances in this industry have been adopted by the cement and concrete industry. In comparison with steel, aluminum, glass and plastics, the energy spent to create a concrete facility is often an order of magnitude less than that needed to create a comparable amount of a competing material. This is because a cement kiln is a very energy efficient device and the energy to make concrete is mainly spent in making the cement. As a result of the increase in energy cost over the past three decades, concrete finds itself in a very favorable position on a first cost basis.

**Desirable engineering properties**

Perhaps the most important property of concrete is its ability to be cast in the shape of a containment vessel and to be relatively impermeable. This enables concrete to be especially effective for domestic water supply and for disposal of domestic liquid wastes. This apparently was the first use made of concrete by the Romans some two thousand years ago and some of the facilities still serve a useful function today. These properties enable concrete to be used to effectively contain hazardous wastes. Hazardous waste also can be incorporated into a concrete mixture so that the objectionable material is immobilized within the mass of the concrete. Wood and clay masonry are the main competitors of concrete in the building industry. The fact that concrete can be cast monolithically into visually attractive forms and can be effectively reinforced with steel reinforcement makes it the material of choice for many designers. The fact that strength, stiffness, and durability are variables in the hands of the designer means that concrete can be made only as good as it needs to be. Unfortunately, as we all know, unskillful or uncaring designers can create structural and visual disasters. Of course when this happens any savings are nullified when a structure has to be repaired or replaced prematurely. The special engineering properties of concrete make it ideal for all types of streets and highways. The surface reflects light, improving night time driving, and does not washboard, rut or pothole. With a proper surface, the risk of hydroplaning is eliminated. A recently released study of fuel costs for trucks running on either an asphalt or concrete test circuit revealed that an 11% fuel consumption savings can be achieved on a concrete road as compared to an asphalt one. This is based on a fully loaded tractor semi-trailer at a test speed of 100 km/hr. For 75 and 60 km/hr the saving in fuel was 8% and 6% respectively. It seems that asphalt pavement deflects more under the truck tire than does the concrete pavement.

**Sink for liquid combustible hazardous waste**

Hazardous combustible liquid waste, not always disposed of in a safe way in the past, finds a ready use in fuelling kilns to make cement clinker and low density aggregates. These wastes are solvents, sewage sludge, used oil and in fact almost any combustible liquid or sludge that can be pumped and has fuel value. However asbestos contaminated waste and radioactive and pesticide based wastes are not normally used.

**Sink for silica rich industrial wastes**

Blast furnace slag and various other solid wastes from the metals refining industry can be disposed of as aggregate for concrete. The most effective way of using blast furnace slag is to pelletize it to produce a low density aggregate with a particle density of 1.4 which makes it competitive with most other low density manufactured aggregates. Alternatively the blast furnace slag can be ground into a powder and used as slag cement to replace some or all of the Portland cement. Fly ash from coal fired electric generating plants can be pelletized and then fired in a travelling grate to produce a low density aggregate. Also the fly ash can be used as a pozzolana to partially replace Portland cement. With the use of slag, fly ash and silica fume as a pozzolana, the CO₂ emission associated with the production of concrete can be reduced by a half or more.

**Thermal mass saves heating and cooling cost**

Heat transfer through a material with a low thermal diffusivity like concrete is slow and the amount of heat stored in it is relatively high. Consequently such a material responds slowly to outside temperature change. In most places there is a large
daily outside air thermal fluctuation and buildings made with concrete tend to smooth out the low temperature that occurs at about 6 a.m. and the high temperature that occurs about 2 p.m. Also, the thermal mass effect causes the peak demand for maximum heating to be delayed from about 6 a.m. to late afternoon. People, equipment and appliances can also effectively reduce the peak heat load as can solar gain from south-facing windows.

The heat loss or gain for very light wall construction with low thermal mass tends to follow closely the exterior temperature profiles and has the potential for excessive interior temperature swings depending on the size and location of windows. High thermal mass material used for wall construction with the insulation placed on the exposed side can play an important role in providing comfortable living conditions while saving energy in the process.

**Green aggregates**

Low density aggregates made from expanding shale, clay, slate or blast furnace slag can be used effectively to make an environmentally-friendly material - lightweight concrete. Lightweight concrete is about 28% lighter than ordinary concrete, and, in a design where the dead load is equal to the live load, a saving of 14% in the energy intensive steel reinforcement can be achieved. For long span bridges, the live load is a minor part of the total load and there a reduction in density is translated into reductions in not only mass but also in section size. This is especially true where prestressing can induce load balancing effects that compensate for the reduced modulus of lightweight concrete as compared to normal weight concrete. Energy savings result from the increased thermal resistance of lightweight concrete which is normally six times that of normal weight concrete. Also because the low density aggregates tend to have a stiffness that matches the stiffness of the cement paste matrix the stress concentrations within the concrete are reduced resulting in fewer micro cracks as compared to normal density aggregates where the stiffness is three to six times that of the cement paste matrix.

The energy input from the manufacture of the lightweight aggregates traditionally has been coal; however in recent years a major part of the fuel requirement has come from the burning of combustible liquid waste products that otherwise would have to be disposed of in an incinerator. In this way the energy input to make lightweight concrete is only marginally higher than normal weight concrete and this is quite insignificant when compared to the energy savings that results from the reduced dead load and increased thermal and durability characteristics of lightweight concrete as compared to normal weight concrete.

**Concrete can be recycled**

Waste generation need not be a problem with the concrete industry as the aggregates can be reclaimed from concrete remaining after placing is completed. This normally only represents about 2% of the total fresh concrete and the concrete sludge remaining after the aggregates are reclaimed can be combined with the water from truck washing. This cement paste sludge can be de-watered, dried, crushed and then used to replace some of the fine aggregate; however it can find its best use as a soil conditioner or as roadbed material, uses that do not incur energy costs. Hydration stabilizing admixtures are now available to enable all returned concrete at the end of the day, plus all water used to wash down the inside of the drum to be saved inside the drum overnight and then used to make up part of the concrete proportions for the first load when work starts again the next day. In this way the fresh concrete is fully recycled.

Recycling of concrete demolition waste is common in Japan and Europe where the cost of disposing of construction waste is high. It entails crushing and sieving to recover the aggregates. In preparing concrete using recycled aggregate, it is necessary to increase the unit quantity of water for attaining the desired workability because the hardened cement paste adhering to the aggregates absorbs the mixing water. Alternatively, the concrete debris after crushing can be used as roadbed materials eliminating the need to use somewhat more expensive recycling procedures.

Discarded automobiles as steel for reinforced concrete Abandoned automobiles that can be a blight on the landscape are collected and after stripping them of the copper wiring, they are processed by an electric arc furnace into steel that can be rolled into steel reinforcement for concrete. This generates much less pollution than using steel from the blast and open hearth furnace that is used for manufacturing the original steel for automobiles.

3. **WHAT IS TO BE DONE**

With the exception of CO₂ and nitrous oxide emissions, all the perceived environmental problems with concrete are or can be effectively addressed using our current technology. Our industry needs to focus on these two greenhouse gases. The Intergovernmental Panel on Climate Change (IPCC) meeting in Geneva earlier this year warned that the average temperature is expected to rise between 1.4 and 5.8 °C over the next 100 years. Five years ago the panel predicted a maximum of 3.5°C rise over the same period. The average global temperature has risen only 0.6°C over the past 100 years.
Greenhouse gases are cited as the cause of these changes. The IPCC is considered the definitive scientific standard that serves to influence government policy around the world and they predict more people will be harmed than will benefit from climate change. Instead of warmer climates more extreme weather - heat waves, floods, drought and windstorms are in the offing.

Industries that cannot reduce their emissions need to pay a carbon tax or they can purchase carbon credits from another company that can more easily reduce its emissions. In this way companies that reduce carbon emissions can sell excess capacity in the form of “credits” to heavy polluters, although ultimately all industry must take responsibility for its own emissions. In the concrete industry the easiest and most effective way to reduce green house gases is to increase the use of such silica rich by-products as fly ash, slag and silica fume thereby reducing the amount of cement used per cubic metre of concrete. Concrete generates about 7% of the total CO2 generated worldwide. About 1625 million tons of cement was produced in 2000. If a ton of cement produces a ton of CO2, and if only 18.5% of the cement can be replaced with slag or fly ash, then the CO2 reduction would be 300 million tons per year worldwide. Over the past decade the average annual increase in CO2 emissions is 1.3 percent or nearly 300 million tons a year worldwide. Our industry alone could easily reduce global warming and at the same time enhance the properties of the concrete produced. Not only can our industry greatly reduce global warming but we can roll it back, as 18.5% cement reduction pales in comparison to what should be used for optimum concrete properties.

4. IMPLEMENTATION

Silica-rich supplementary materials such as fly ash, slag, silica fume, calcined diatomaceous earth, rice husk ash, and heat treated shale are all suitable candidates to replace Portland cement and at the same time enhance the properties of the concrete. There are two ways to incorporate one or more of these silica-rich materials into the concrete mixture. The older method is to simply add the cement and the supplementary cementing material to the mixer separately. This requires that ready-mix firms have additional storage facilities for the supplementary cementing materials. Alternatively a private company might contract with the by-product producer to take their output and sell it to the ready-mix concrete producer. The other method is to use blended cement in which the silica rich material is added at some stage in the manufacture of the cement. Usually it involves inter grinding it with the cement clinker. It is important at this stage to point out that all of this has been done in many places for several decades and is well accepted by the industry generally even though on a worldwide basis little supplementary cementing material is currently being used

The price of the supplementary cementing materials depends on the method of production - whether added at the mixer or added as blended cement. Restraint of trade legislation will hopefully prevent the multinational supplier of blended cement from pricing the blended cement and normal Portland cement at such a level as to prevent the establishment of an independent supplier of supplementary cementing materials. In any event not only is the price of producing concrete being reduced regardless of how the supplementary cementing material is handled, but the quality of the end product is enhanced.

5. SELLING THE IDEA

The large companies and industries that are on the wrong side of environmental and social issues know how costly it can be and are now thinking of a “triple bottom line” that includes not only profitability but also social and environmental factors as well. In controversial matters, good sense and regulatory compliance are not always enough. You need to be open and honest with the public about the risks. Social problems that reflect badly on our industry will not go away. Likewise if we can easily improve our performance in a big way by the use of supplementary cementing materials, and in various other small ways, we should do so. The public will recognize that corporate attention in the cement industry is now focused on being a sustainable business that has not only a financial but also a social and environmental dimension as well, and that we can truly refer to concrete as being "green".

6. ENVIRONMENTAL PROBLEM SOLVING

Traditionally, the elites responsible for managing environmental problems have retained control of the problem-solving process, occasionally seeking technical and other information from their expert advisors, while excluding the broader public from meaningful involvement. Although such technical organizations as the American Concrete Institute and the International Federation for Structural Concrete (fib) serve our technical needs well, it seems we need a better window to the public and I believe that the United Nations can provide the appropriate forum for announcing what good things concrete can do for our environment.
The United Nations Environment Program (UNEP) can provide an international forum to promote the idea of “green” concrete and what our industry can do for the environment. In 1997, UNEP published Technical Report No. 38 on the “Steel Industry and the Environment” - Technical and Management Issues”, which described what the steel industry and to reduce its negative impact on the environment. I suggest we ask UNEP to turn their attention to concrete and to do a similar report. In this way the ideas from all countries could be consolidated in one document in a form that the international business community might recognize. This would give the supporters of the Global Economy an opportunity to prove their commitment to the environment - in particular the multinational companies who control so much of our concrete industry.

REFERENCES