

DEVELOPING CONCRETE TECHNOLOGY ALONE MAY NOT BE HELPFUL FOR SUSTAINABLE DEVELOPMENT ACCORDING TO THE HOLISTIC VIEWPOINT

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Abstract

The advancement of concrete technology can reduce the consumption of natural resources and energy sources and lessen the burden of pollutants on the environment. However, if the price of environment resources and thereby the cost of concrete still keeps relatively low, then because of the economic rules governing the market's behavior preferring cheaper resources and something with good quality but a lower price, more environment resources and concrete materials will be used and they will not be cherished and saved, which will result in the worsening of environment. An accurate method is to add a suitable environmental cost of producing concrete into the current price by adjusting the price of environment resources to elevate concrete's price, which will be helpful for protection of the environment and will promote the advancement of concrete technology. The holistic viewpoint is applied in this paper. The problems of sustainable development should be considered on the society-economy-technology level.

1. Introduction

When 1-ton cement clinker is produced, about 1-ton carbon dioxide gas, a kind of greenhouse gas, is emitted. When more than 100 kilograms of standard coal is

consumed, a lot of sulfur dioxide gas, nitrogen oxide gas and mill dust are emitted, which can harm the health of people. Secondly, exploitation of clay as a raw material of cement production, and sand and stone as an aggregate of concrete has destroyed the natural environment, which has resulted in soil and water loss, as well as caused the changes of stream ways. Furthermore, use of a large quantity of fresh water for concrete is a heavy burden, especially in this water crisis era. In addition, concrete will turn into huge non-degradable solid waste after it is out of commission. It is a very crucial problem for human society and the environment in which we are living.

Because of the above reasons, the concrete industry has threatened sustainable development. So we must advance concrete technology to meet the needs of today's generation without endangering the possibilities of future generations to satisfy their needs.

Although concrete is not a green product as a whole, it has been used to construct a wide variety of structures due to its irreplaceable capability in many aspects. As an artificial engineering material with relatively good quality but lower price, nowadays concrete still prevails among construction materials. Its used quantity per year is over 8 billion tons.

However, the pollution caused by producing concrete and the consumption of natural resources is so serious that the position of the traditional concrete industry has to be improved to insure sustainable development. But the total quantity of pollution and consumption of resources and energy has not decreased with the advancement of concrete technology, which has caused a debate over whether only the development of concrete technology can arrive at the goal of sustainable development.

2. Concrete Technology Contribution to Sustainable Development

2.1. Advancement of technology and energy consumption

With the advancement of technology, unit energy consumption for cement has decreased on the whole. Fig. 1 indicates the trend of energy consumption for cement

in China. But because of the increase in cement production (see Fig. 2), the total energy consumption has increased. Fig. 3 shows the increase of total coal consumption for cement in China. In the world, the cement production has increased nearly linearly, which leads to the reduction of unit energy consumption (see Table 1) but cannot hold back the increasing trend of total energy consumption. Other aspects such as emissions of carbon dioxide gas have had these similar conditions as well. (Source of data in Figs. 1 and 2.: *China Energy Statistical Yearbook* [1997-1999] and *China Industry Economy Statistical Yearbook* [2002].)

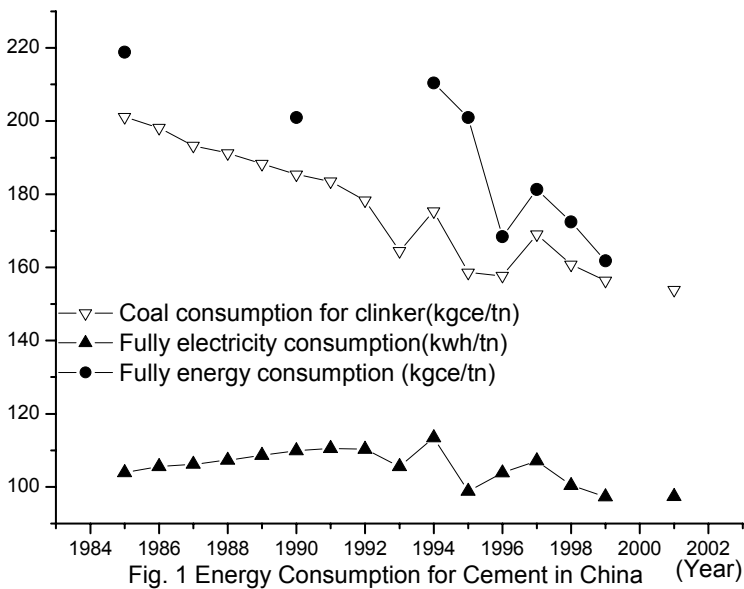


Fig. 1 Energy Consumption for Cement in China (Year)

Although reduction of unit energy consumption helps to cut down a large quantity of energy consumption with the rapid increase of cement production, the rise in total energy consumption has not been effectively controlled. While it cannot be denied that concrete technology has made prominent progress during the last half of the twentieth century, neither can it be denied that the exigent situation of the environmental problem has harmed the sustainable development of society. That is to say, if the concrete technology continues to progress in its current path (here only the technology is considered), then the problem of sustainable development cannot be resolved yet.

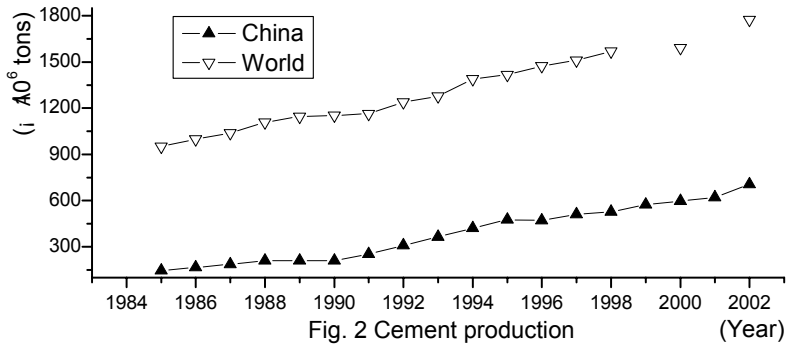


Fig. 2 Cement production

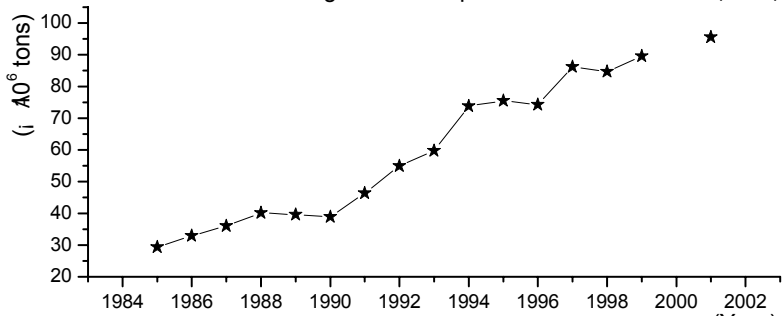


Fig. 3 Total coal consumption for cement in China (Year)

Table 1: Energy consumption in Japan and Germany

Japan	Fully energy consumption for cement (kgce/tn)				
	1980 (y)	1990 (y)	1995 (y)	1997 (y)	1999 (y)
	135.7	122.6	124.4	124.6	124.4
Germany	Fuel energy consumption (specific in kJ/kg cement)		Electrical power consumption (specific in kWh/tn cement)		
	1999 (y)	2800	102.0		
	2000 (y)	2835	101.5		
	2001 (y)	2790	99.8		

Source: *China Energy Statistical Yearbook (1997-1999)* and *Environmental Data of the German Cement Industry*.

2.2. Environmental cost and concrete technology

In environment economics, environment is regarded as a necessary resource for production and also has value and use-value like other resources. Here environment resources include natural resources and environment services. Environmental cost is defined as payment for use and consumption of the environment resources. Fig. 4 shows that environment resources play a necessary pole in concrete production process.

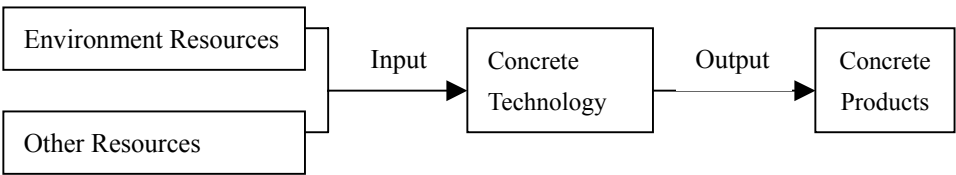


Fig.4: Environment is used as a resource in concrete production process

If the prices of environment resources are undervalued, that is to say, no or a little environment cost is reckoned in the total cost of concrete products, two results will be caused: (1) Because of lower price of environmental cost, more natural resources and environment services will be used. In order to reduce consumption of environment resources, more other resources, for example, manpower resources, green technology and equipments, power, etc. tend to be used. This expenditure is a part of environment-protection cost. Obviously cheaper resources would be firstly chosen and more used; (2) Because of lower price of concrete products, the materials will especially not be cherished and saved.

Here we define the term Green Factor to describe the degree of concrete technologies' contribution to sustainable development. The concrete technology with higher green factor will use less environment resources.

Some concrete technology has a relatively higher green factor, which directly contributes to sustainable development. For example, reduction of the quantity of cement clinker in the condition of the same strength grade by mixing fly ash or slag

instead of partial cement, saving the energy used for concrete, and circular utilization of concrete that is out of service could all contribute to this goal.

As a result of the fact that many concrete technologies with high green factor may increase the cost by using less of cheaper environment resources and more of more expensive other resources, they may be unacceptable while those with low green factor may prevail.

When the cost paid for use and consumption of environment is cheap, the advancement of concrete technologies, even those technologies with high green factor, is helpless for lavishing natural resources and environment services, but may be helpful for improvement of concrete performance. Thus concrete becomes a material with good quality but a lower price.

Therefore, a concrete technology is unwelcome unless it could use less environment resources than before without elevating the price of concrete and largely harming the concrete performance at least. For example, if we use the old concrete from structures that are out of service as recycled aggregates of new concrete, it must be guaranteed that the cost for obtaining these recycled aggregates is not more than that of natural aggregates and the concrete performance won't be greatly harmed.

Therefore, the criteria for evaluating whether advancement of a concrete technology is completely helpful for sustainable development or not are below:

- Use less environment resources without increasing the cost of concrete products.
- Use less environment resources without greatly harming concrete performance.

A concrete technology will really contribute to sustainable development only when both of the criteria are satisfied. The first criterion, to a large extent, is depended on economic rules and policy while the second one is completely a technology problem.

2.3. Advancement of concrete technology on condition of lower environmental cost

Now the prices of natural resources mainly contains exploitation cost and no or a little environmental cost. A little expenditure has been paid for environment services in processing, circulation and consuming of products.

Nowadays, one of the reasons why concrete products are used so widely is their lower price. This is primarily because most of the environmental cost has not been reckoned in the practical total cost or only a little of it has been considered. For example, the cost of the greenhouse effect caused by the huge volume of carbon dioxide gas emitted by the concrete industry is shared by the whole society and even future generations. It is unfair to those who do not reap the benefits brought by the concrete industry, yet suffer the consequences. Fairness just should be one of most important principles of sustainable development.

Since the total cost of concrete includes either no or a little environmental cost and the technologies with higher green factor, as mentioned above, shall add the environment-protection cost to the price of concrete in practice, manufacturers would prefer to support technologies without a green factor more than those with a higher green factor. Thus the concrete product can still keep a lower price after it is provided with good performance. This is one of the main reasons for a lower price level of concrete. Here is an example concerning the lower price of concrete: in the year 2000, the total income on sales increased only 5% in the condition of 4.2% increase of cement production in China [1].

Thus, an economic rule governing the market's behavior preferring something with good quality but lower price, will inspire people to select more concrete material for construction instead of other building materials probably with higher green factor. Concrete materials will especially not be cherished and saved, which will widen the gap between the concrete industry and sustainable development.

The rule dominates the economic activity in the concrete industry so that the influence of technology is relatively weak compared with policies of technology and economy.

In other words, the development of concrete technology alone may not be helpful for sustainable development. In fact, it may even sharpen the conflict between the concrete industry and sustainable development.

The advancement of technology with higher green factors is one of the most effective ways to resolve the problem that the concrete industry has hindered from sustainable development. The technology has played an important role in narrowing the gap between the concrete industry and sustainable development. However, in order for these technologies to be effective, some measures should be taken to insure real price of environment resources.

2.4. Reckoning in environmental cost and its advantage

An accurate method is to add suitable environmental costs of producing concrete by adjusting the price of environment resources into the current price to elevate concrete's price, which will be helpful for protection of the environment and will promote the advancement of concrete technology. In fact, once given an environmental cost, the concrete will not be a cheap product and will have a higher scarcity than before in the market. On one hand it would encourage users of concrete to cherish and frugally use it and thereby reduce irrational use of concrete or look for other preferable construction materials with advantages both in economy and in environmental protection. On the other hand, it would encourage manufacturers to afford funds to support the study of concrete technology by which the environmental cost can be lowered and therefore excess profit can be gained. This is helpful for the scientific research on concrete and even development of new building materials. In this sense, sustainable development not only brings challenge but also offers a hard-won opportunity for concrete technology.

In fact, the reasons why technologies with higher green factors have not made great progress may partially be ascribed to less attention being paid by relevant organizations. Enterprises, the key players in the market, have not responded to the fact that a lower price of concrete can not attract enough attention in economic activity. In addition, environmental costs may be regarded as the currency value of the

needs for sustainable development and reflect the justice of society among contemporaries and future generations as well.

Conversely, the essence of the environmental problem is that, in economic activity, the gaining speed of a resource from nature exceeds the regenerating speed of the natural resource and its replaceable resource. However, the expelling amount of waste due to human activity into the environment exceeds the depurating capability of the environment itself [2]. Therefore, the environmental problem essentially is an economic one.

Exorbitant environmental costs may resolve the environmental problem but may stifle the economic development; therefore, environmental cost must shoot for achieving a balance between economic development and environmental protection.

In fact, as a result of higher environmental cost in developed countries, their needed cement is imported from developing countries where the price of environment resources is relatively lower.

3. On the Holistic Viewpoint

The harmony of concrete technology and sustainable development must be discussed according to a holistic viewpoint. An idea that may be right in a certain domain, may be wrong in a wider spectrum. Just as in this case, the advancement of technology seems helpful for sustainable development but may not be integrated in the system of society-economy-technology.

Sustainable development is a global project including all realms and trades. Therefore, the relationship among the economy, society, and technology should be considered properly when we make our efforts to improve the technology.

In holism, whole is emphasized. However, the concept of whole is relative rather than absolute: A whole is the part of another larger whole. In different levels, there are

different wholes. Therefore the holistic viewpoint is confused unless the level and range is applied and defined. An accurate conclusion that is identical with reality to a great extent depends on the basis of an accurate definition of level and range.

Nowadays, the issue of sustainable development should be considered in society-economy-technology level. In this level, the cost of concrete, including the consumption of natural resources, environment services and energy and use of manpower, equipments and facilities, and so on, should be analyzed during the whole lifetime of the material with the method of life-cycle assessment (LCA). It is in this level that the problems of the development of concrete technology besteding sustainable development can be resolved through the composite effect of economy, society and technology. This includes the decrease of consumption of resources and energy, the reduction of drainage pollutants, the improvement of durability of concrete materials, the use of recycled concrete and the invention of new materials with higher green factors.

In addition, according to the viewpoint of eastern philosophy, the holistic viewpoint should be a capacity through which a thing can be intuitively grasped on the whole. It is an approach through which the key of a problem can be caught but those secondary details are overlooked. The holistic viewpoint encompasses wisdom with which you can go out of the situation and survey the problem at a higher level.

4. Conclusion

According to a holistic viewpoint, despite the decrease of unit energy consumption, the total quantity cannot be reduced if the concrete production increases due to a lower price. This economic consequence would result from an advancement of technologies with little green factor and a lack of suitable environmental costs. Other aspects of the concrete industry such as emissions of carbon dioxide gas have had similar repercussions as well. The development of concrete technology without the support of the relevant policies of economy and law may be not helpful for

sustainable development. Thus it can be seen that a holistic approach is important for science and technology research.

Acknowledgments

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References

1. *China Building Industry Yearbook*, 2002.
2. Luo Yong and Zeng Xiaofei. *Economic Means for Environment Protection*. Peking University Press, 2002.