

INTEGRATING SUSTAINABILITY CONCEPTS INTO THE DESIGN PROCESS FOR CONCRETE CONSTRUCTION INNOVATIONS

The University of Tokyo Graduate Student Student Member Michael Henry
The University of Tokyo Associate Professor JSCE Member Yoshitaka Kato

1. Introduction

Construction of concrete infrastructure can be thought of as the process of transforming raw materials into a useful engineered artifact. This transformation process requires cooperation between many different actors, each utilizing their specialized information and knowledge to help with the transformation process. For example, design engineers specify a required level of concrete performance necessary for the infrastructure; manufacturing plants have to produce fresh concrete from raw materials, contractors must place fresh concrete into the structural form shapes and manage curing until the concrete meets the specified performance level.

Each of these actors not only brings specialized knowledge, but has specific considerations regarding the production process. Therefore, the design process for creating a new concrete material innovation should consider the total needs of all the involved actors. Concrete, as a material artifact, should be designed, at each phase, in consideration of the needs of the user who is concerned with the concrete at that phase.

As sustainability becomes a stronger force in the construction industry, the means for producing concrete infrastructure will change. An understanding of the needs of the actors involved in concrete construction, as well as how to integrate new actors, is vital for the successful implementation of material innovations to meet the demands of sustainable development.

2. Concrete as an artifact

2.1 Design process

Concrete infrastructure may be thought of as an artifact; concrete material itself may also be considered as an artifact. Each of these artifacts has a design process whereby they are transformed from media to an artifact by the transcription of design information, as illustrated in Figure 1.

2.2 Material development

Concrete construction requires cooperation between different actors, each of whom has specific needs. The material development process should begin by identifying

these actors and their specific needs. Once these needs are identified, the artifact can then be developed based upon these needs. As a result, the final form of the artifact is driven by feedback given by prospective actors involved with the artifact.

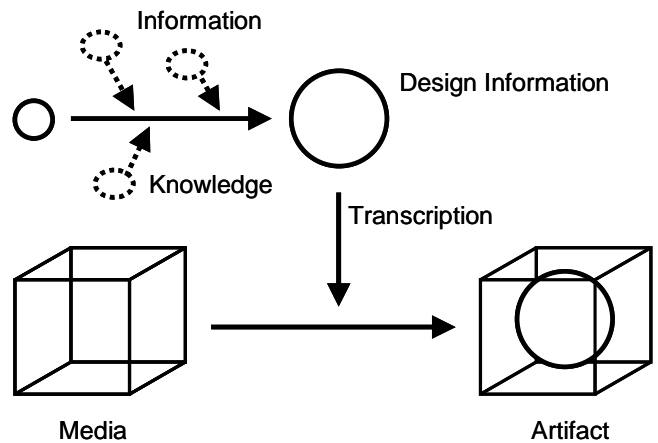


Figure 1 Artifact design process [1]

2.3 Concrete construction

The construction process is composed of several phases in which one form of media is transformed into another. Limestone rock and minerals are converted into Portland cement; Portland cement is mixed with water, admixtures, and aggregates to produce concrete; concrete is placed in forms and cured to create a concrete structure (Table 1). In each of these phases, design information is being applied, based on specifications, past experiments, experience, and so forth, in order to successfully create the artifact based on some given requirements.

Table 1 Transformations in concrete construction

Media	Artifact
Limestone, minerals	Portland cement
Portland cement, water, aggregates, admixtures	Concrete
Concrete, formwork, reinforcement	Concrete infrastructure

Keywords: sustainability, innovation, concrete management

Address: 4-6-1, Komaba, Meguro-Ku, Tokyo 153-8505, Japan. TEL 81-3-5452-6098(58090)

3. Sustainability and concrete management

3.1 Defining sustainability

Sustainability is a term used to describe practices which meet the needs of the present without compromising the ability of future generations to meet their needs [2]. For the concrete industry, this presents significant problems as the world consumption of concrete is increasing due to increasing urbanization and demands for infrastructure necessary to meet basic living needs.

The American Concrete Institute (ACI), along with the Portland Cement Association (PCA), organized the Concrete Summit on Sustainable Development in March 2007. At this summit, opportunities for sustainable development in the concrete industry were identified as energy consumption, generation of greenhouse gases, land use, resource consumption, dust and diesel emissions, and reduce/reuse/recycle applications. To maintain concrete as a competitive construction material, the industry should focus on fire and force protection, thermal mass, and durability [3]. These concepts fall within a greater framework for sustainable development, shown in Figure 2.

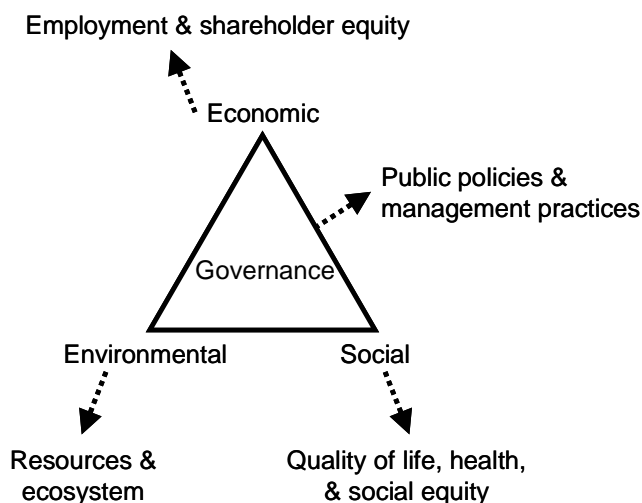


Figure 2 Sustainable development framework [3]

3.2 Integrating sustainability concepts

Traditionally, the information and knowledge involved in developing the design information is based on engineering traditions and principles. However, when considering the needs for sustainability, these engineering principles alone are no longer sufficient. Therefore it is necessary to utilize the knowledge provided by other fields, such as sociology, economics, or environmental engineering, to develop a more comprehensive approach to managing concrete innovation (Figure 3).

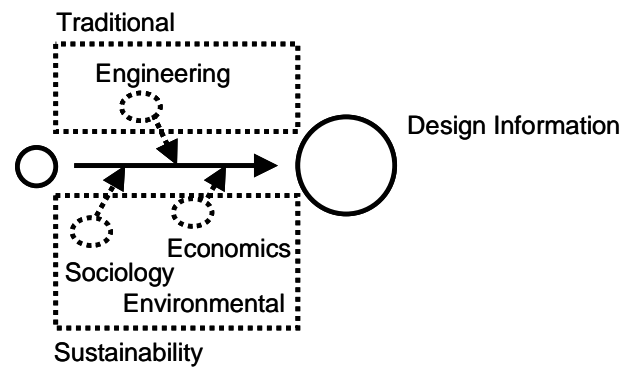


Figure 3 Integrating sustainability concepts into design information

The integration of other fields' knowledge will necessarily require their input as participating actors in concrete construction. In some cases, the final form of the artifact developed may change as a result of new input; in some cases, the final form may remain the same but the process for transforming the media to the final product may change; finally, it's also possible for the process and final product to remain the same but the process to become cheaper or have a reduced environmental impact.

4. Conclusions

Concrete plays an important role in the construction of the world's infrastructure. Perhaps because of this role, the concrete industry should also serve as a leader in adopting sustainable concepts. Sustainability will drive changes in the way the concrete industry operates, with a shift away from pure engineering to an integration of multiple sciences, such as sociology, economics, and environmental engineering. Actors from these other fields can contribute the knowledge necessary to innovate practices in the concrete industry towards a more sustainable future, but the means by which their knowledge is integrated into the concrete construction process should be clearly understood to facilitate cooperation and collaboration.

References

- [1] Yoshida, S. and Yashiro, T., "Study of the basic logic of diffusion using specific models," PICMET'07, Portland, Oregon, USA, August 2007.
- [2] United Nations, "Report of the world commission on environment and development," General Assembly Resolution 42/187, December 1987.
- [3] Bédard, C. and Sordyl, D., "Concrete summit on sustainable development," ACI Concrete International, July 2007, pp. 54-58.