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Assessing Potential Development in South Korea's Supertall Building Technology


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This paper evolved from an initiative launched in 2010 to investigate the status of fundamental technologies necessary for the construction of supertall buildings in South Korea. A study led by the CTBUH assessed the potential benefits of these technologies, compared the current level of expertise in South Korea with other countries, and gauged the potential of developing that expertise and its impact on the construction industry in South Korea. This methodology can be used by other countries to predict technological progress and areas to be developed.

Introduction: A Review of Tall Buildings in South Korea

Three decades of extraordinary growth have transformed South Korea from one of the poorest agricultural economies to the 11th largest economy and exporting country in the world. This rapid development was driven by very high rates of savings and investment and a strong emphasis on education, which boosted the number of young people enrolled in universities to among the highest levels in the world (Nationsonline 2012).

Construction also played an important role in South Korea's growth. The level of economic growth has led to a sharp increase in the number of tall buildings in South Korea. There were only nine buildings 150 meters or taller in 2000; by 2012 there are expected to be approximately 135 buildings taller than 150 meters. Far from abating during the global economic crisis, the pace of tall building construction is increasing, spurred by economic growth and business achievements (see Figure 1). Two out of ten of the country's future tallest buildings are currently under construction and five more are in the proposed design phase.

These impressive statistics have brought South Korea to the forefront of the tall building industry, with only four countries globally containing more completed 150 m+ buildings: China (782), USA (653), Japan (154) and the UAE (131). Currently, South Korea has more 150 m+ buildings under construction than the United States, the United Kingdom, Russia and Japan combined (see Figure 2).

South Korea's increase in tall building development has been steady compared with other countries in the region. The pace of construction has accelerated in recent years, with roughly 50% of the total number of buildings taller than 150 meters completed in the past three years alone.

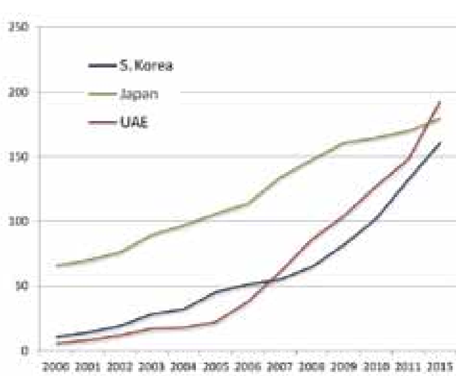

Figure 1. Growth curve of tall buildings in South Korea, Japan & UAE. © skyscrapercenter.com

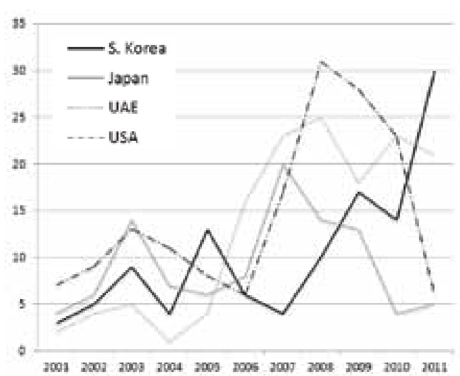

Figure 2. Comparison of number of tall buildings higher than 150 meters in South Korea, UAE, Japan and USA © skyscrapercenter.com

Today, South Korea only has two completed "supertall buildings" – the Northeast Asia Trade Tower and Doosan Haeundae We've the Zenith Tower A – following the CTBUH's definition of a "supertall" as a building higher than 300 meters. However, more than 4 supertalls are presently under construction and 26 have been proposed, either as a project or a vision (Cho & Chung 2011).

Core Technologies in Supertall Building

The rapid increase in tall buildings has led to a need to understand the technologies and engineering developments used for projects of this magnitude. The application of new technologies in any country depends on many aspects, from an understanding of the technicalities of the new technology, to the flexibility of the codes to allow new ideas, to the willingness of a designer or builder to try new approaches and accept the challenges and risks that go along with it.

In 2010 the Korean government launched a comprehensive research program on supertall buildings to obtain the core technologies needed for a comprehensive level of tall building expertise within Korea.

As the program progressed, the Korea Institute of Construction Technology (KICT) commissioned the CTBUH to conduct a study to compare the current level of expertise in South Korea with other advanced countries and determine its impact on the construction industry of supertall buildings. The KICT created a "technology tree" including four basic research areas: core engineering technology, maintenance and disaster risk reduction technology, materials and construction technology, and project management technology.

Eleven sub-areas were identified in the Level 2 and 23 research projects in the Level 3 (see Figure 3). Based on this technology tree, a questionnaire asked experts to evaluate the current level of these technologies compared to the ultimate level of each technology.

The study measured the comparative level of technologies of supertall buildings and forecast the realization time for each technology. Each technology has been studied and analyzed with consideration of four major parameters which are the key for future developments: strategic importance, secured capacity, exclusive market and economic impact.

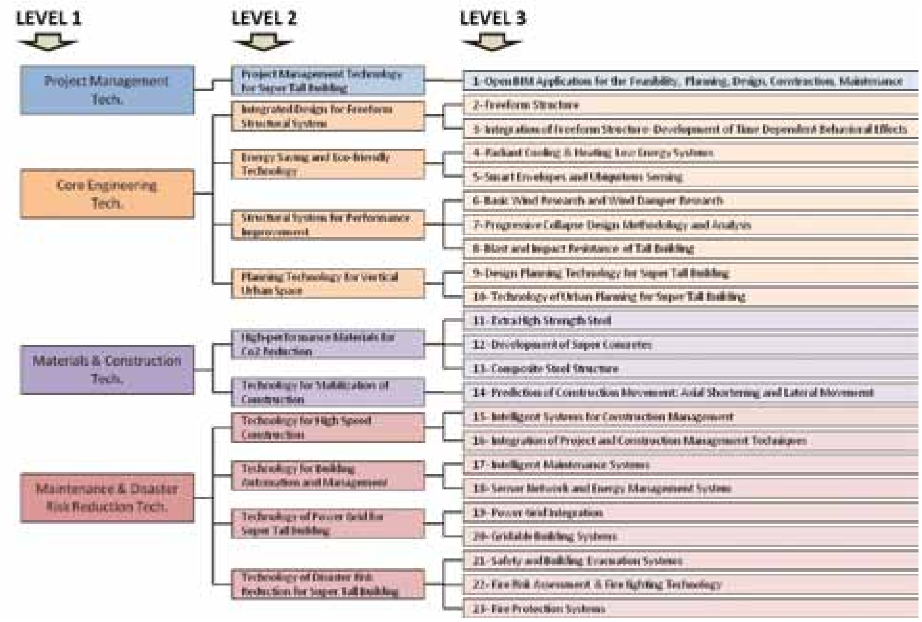

Figure 3. Technology tree in supertall buildings. © KICT

These major parameters have been studied in the following areas: level of technology in 2011 and 2015, technology growth curve between 1990 to 2040, stage of development of leading organizations and South Korea, strategically, sustainability, market share, exclusively, cost saving, time saving, safety and maintenance.

Research Methodology

The technology development focused on two levels:

a. "Perceptional technology level," measuring the level of certain technology based on an expert's experience and knowledge,
b. "Ultimate level," the highest level (100%) of technology that can be ideally reached by research and development efforts.

The survey techniques for measuring technology development perception level are broken down into several types in consideration of technology life cycles and time periods. In the past, irrespective of the technology life cycle, the gaps with top technology leader nations or organizations was determined in terms of percentage. However, these days, dynamic profiles of changing technology development levels are better determined on the basis of five stages of a technology growth curve, including introduction, growth, expansion, maturation and decline. Such survey techniques are also used to determine the number of years required for reaching an ultimate upper limit, measuring the rate of technology evolution in Korea and other leading economies. The technology growth curve is known as an S-shape curve of technology development based on an assumption which has a dynamic life-cycle. The many measurable development stages are as follows (see Figure 4):

- Introduction: introduction of an idea
- Growth: being developed from its introduction
- Expansion: rapid development and being expanded
- Maturity: applying superiority and diversity of developed technology
- Decline: declining the superiority of technology and falling in its market value

The study was implemented using the Delphi Method, a systematic forecasting process based on a panel of experts. The Delphi method relies on a structured group of individuals to forecast a common trend. This is sometimes referred to as "collective intelligence." Traditionally the Delphi method has aimed at a consensus of the most probable future by iteration (Linstone & Turoff 1975).

For the purposes of the study it was decided the comparison would be between South Korea and a series of leading countries or organizations advanced in their construction techniques, including the United States, United Kingdom, France, Canada and Japan. Then two separate survey groups were developed, consisting of multidisciplinary experts from both the professional sector and academia, representing South Korea and international. These experts then gave their opinions on the measurement and realization time of key technologies in tall buildings in their areas of expertise.

An online questionnaire was designed to focus on problems, opportunities, solutions, benefits and forecasts. Each subsequent questionnaire was developed based on the results of the previous questionnaire. The process was stopped when the research question was answered: for example, when consensus was reached, theoretical saturation was achieved or when sufficient information had been exchanged.

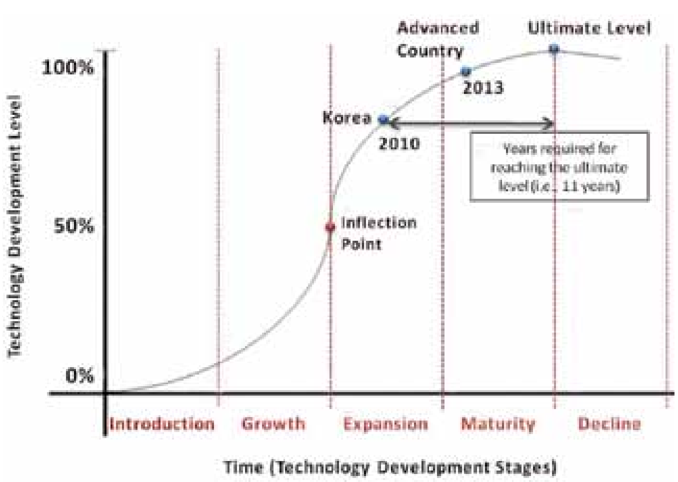

Figure 4. South Korea technology growth curve compares to other developed countries. © Authors

The online questionnaire divided the major questions into two areas: measurement of technology level and core technology assessment criteria in 23 topic areas of the technology tree.

Of the major respondents 75% were from architecture, engineering and construction firms and 25% from universities and research institutions.

Assessment and Analysis of Results

The initial questionnaire was answered and returned by a panel of experts on subjects in the construction industries. The data was evaluated using Dynamic Technology Level Analysis that enables the calculation of present and future levels of each technology presented by the KICT. This analysis facilitates the work of researchers by estimating the development tendencies of each of the technologies, and determining any possible gaps between Korea and other advanced countries.

The analysis focused on the following key areas:

- *Core technology assessment criteria*. The expert's opinion and perception of the potential value and benefit of the research being carried out.
- *Strategic Importance.* Strategic necessities that should be considered in order to have market access and securing competitiveness. This area included the generic technology/connectivity, evaluating whether it is a core technology that can be used for development or application of other technology; and also has high connectivity to other technology. The evaluation also considered green and energy efficiency: whether it is a technology that can have a strategic dominant position with respect to CO_2 reduction and energy saving.
- *Secured Capacity.* A technology that has been developed which provides foundations to develop core technologies and applications to commercialization.
- *Exclusive Market.* A technology that can secure exclusive market(s) in the world with its originality and creativity after development.
- *Economic Impact*. A high value added technology with respect to reduction of duration, cost saving, market value and maintenance effect.

From the reviews given by experts, in 2011 South Korea is in the low and middle level of technology development, but it will improve to middle level on most technologies by 2015. Figure 5 shows key technologies and the experts' predictions on their tendency.

The analysis of the study shows that BIM application in South Korea has a very high strategic importance and economic impact. BIM applications also experience an exclusive market which allows it to have a high projection in the future. South Korea's expertise in science and technology have grown steadily since the 1980s, as the country's rapid economic development has demanded more advanced and dynamic research and development activities. Over the next five years there will be substantial development of BIM technology on all building systems as BIM provides more intelligence and more interoperability between systems and design. Any research and development in this field may have other unexpected benefits.

Economic impact is observed to be significantly high in the vertical transportation technology. This technology achieved high marks in strategic importance, secured capacity and exclusive market categories.

When evaluating the technologies by strategic importance, the most significant are: renewable energy, control technology and urban planning. However, none of these technologies approach high economic

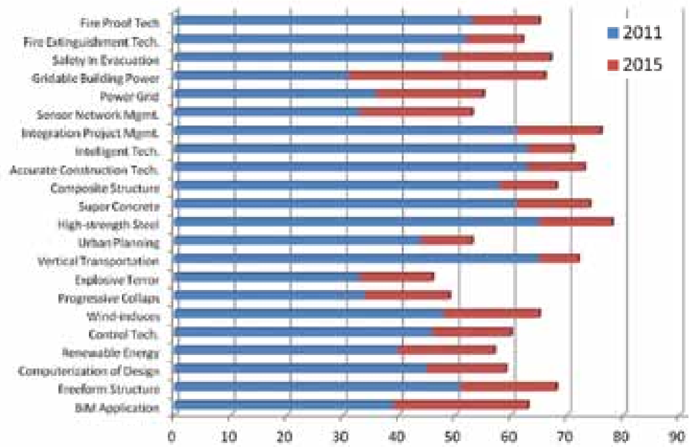

Figure 5. Perceptional level of core technologies in South Korea, 2011–2015. © Authors

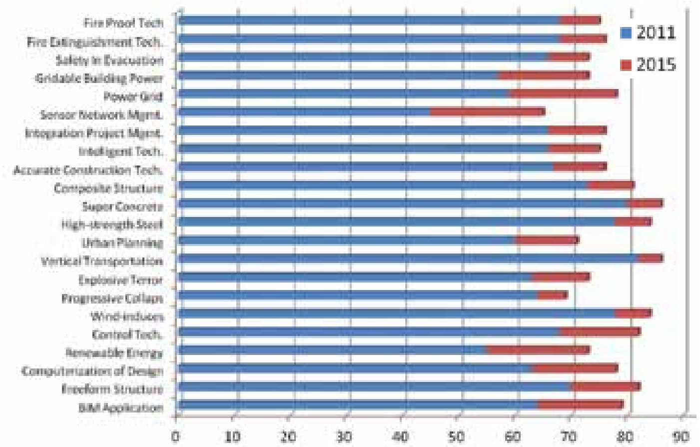

Figure 6. Perceptional level of core technologies in developed countries. © Authors

impact. On the other hand, technologies such as computerization of design, renewable energy and wind-induces project an exclusive market in the future. The study suggests low strategic importance and economic impact projections for both progressive collapse and explosive terror.

The same strategic impact importance can be given to high-strength steel, super concrete, composite structure, sensor network management, power grid and gridable building power. At the same time, none of the technologies with very high strategic importance showed a high projection in economic impact. However, technologies such as intelligence maintenance, sensor network management, power grid and gridable building power scored as high as exclusive markets. The analysis of the study also predicts a very low strategic importance and economic impact for safety in evacuation and accurate construction technology.

The results of the South Korea perception levels show that three technologies – integration project management tech, super concrete tech and high-strength steel – will move from middle level to high level in four years, while minimum growth will affect vertical transportation. Also, target improvement will be seen in gridable building power technology and BIM application technologies. The technologies with the least projected improvement are vertical transportation and intelligent technology; however, they are both in the high importance range (see Figure 5).

The results for advanced countries are very different. The technologies with target improvements are: sensor network management and power grid, although they still fall in the middle category of importance. Super concrete, high-strength steel and vertical transportation have the highest projected importance by 2015 (see Figure 6).

This analysis found medium to small gaps between other countries and South Korea in all 23 technologies. This difference becomes most evident in technologies such as wind-induced vibration control technology, prevention technology of progressive collapse and in fire-proof performance securement technology, where Korea falls behind significantly. The gap becomes less pronounced in areas such as high-strength steel-concrete composite structure, accurate construction technology for compensation of lateral movement and intelligent maintenance technology, where the difference between the countries is almost zero.

Conclusion

The results of this research indicate that there will be substantial development in several technologies including; BIM on all buildings systems and designs; ubiquitous sensing technology in a sustainable and efficient way; sensor network and energy management systems; and smart grid technology with real time monitoring in the future of supertall buildings.

This study can be used as a model for technology development in developing countries. For such research, a ten-year period is suggested to assess development which may show a significant improvement between investment and outcomes. This model research is important in measuring existing levels of technology and determining the realization time required to achieve the ultimate level. These studies would help the industry better understand what technologies are worthy of investment and the level of local and international benefits. ■

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