Global Challenges and the Role of Civil Engineering

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Chapter X
Global Challenges and The Role Of Civil Engineering

Žiga Turk

Abstract The world is going through some profound changes: automation and general improvement of productivity is resulting in the abundance of industrial products, the domination of the West in global economy and politics is challenged by the rise of the BRICS economies, climate change is requiring a reconsideration of the energy system, particularly in Europe demographic changes are resulting in an ageing society, and finally, the electronic communication revolution is changing the ways in which elements in a society are held together influencing all aspects of economy, research, learning, living, media etc. Civil engineers and their forerunners have been shaping the infrastructure of societies for millennia. This paper explores how the listed trends will affect the civil engineering work and were civil engineers will be able to contribute. While the relative contribution of the construction industry to the jobs creation and economic growth will continue to decline, there are substantial opportunities in comparison with some other engineering industries, in particular in the area of climate change and globalization. There are some lessons; in particular with earthquake engineering – the notion of resilience - then can be borrowed by economics and finance.

Keywords: Global future, civil engineering, construction, climate change, demography, information technology, earthquake engineering

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13.1 Introduction

Civil engineers have been providing the infrastructure of the societies since the very beginning of civilization. Although the term "civil" appeared as the opposite of the "military" engineers, the term "civil engineering" gives justice to the role our profession has in society. In the beginning of the 21st century a lot in this society is changing. The long term global trends will be described in Section 2. Section 3 will address some general features of these trends. Section 4 will explore the impact these trends will gave on construction in general and on earthquake engineering in particular as well as what solutions our profession has there to offer.

13.2 Global Trends

The world is going through a series of disruptive changes, which, when coupled with the economic crisis, create a significant discontinuity. The future will not be like the extrapolation of the present but in many ways "a grand transformation" (Reinhardt and Roos, 2008).

The five grand transformations may be listed alphabetically as:

a) Automation and abundance;
b) BRICs: Brazil, Russia, India, China, India and globalisation;
c) Climate change and energy;
d) Demography and ageing;
e) E-everything, information, technology, computers, everything electronic.

13.2.1 A - Abundance and Automation

Increased efficiency of manufacturing processes, automation and robotics are enabling the industry to produce more and more with less and less work. Markets are saturated with products that consumers hardly need at all - especially the consumers in the rich societies with money to spend (Pink, 2006). A significant shift in economy is taking place where the industrial jobs are being replaced by jobs in services; routine production jobs are replaced by jobs non-routinely creating or caring (PISA, 2009; Levy F and Murnane, 2007). Increasing share of the purchase-value of a product is not in the material, energy or routine labor embedded in the product, but in the meaning that a product (or service) evokes in the consumer. Products and services of the future are not only performing the basic function. They are well designed, beautiful, of a known brand, with a positive ethical connotation - "home-made", "environmentally friendly", "trustworthy", "ethically produced", "green" … (Stehr, 2008; Turk, 2008).

While growth in the developing economies and poorer segments of the developed ones is possible in the old way, the challenge of the developed societies is how to create new needs. Re-shaping those needs from material to symbolic is a great challenge for a society as a whole. It will not only grow new domestic industries but could also help save the planet.

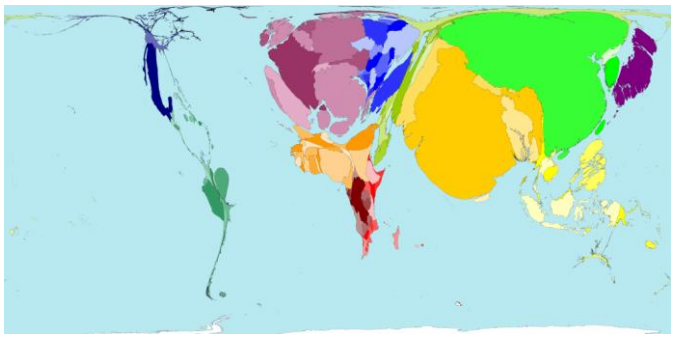
The EU can either use its rich cultural and ethical capital or reorient its economy towards a creative economy, by combining science, innovation and creativity to create products and services that are more than what they are useful for; maintain its world class brands and create new ones that embed our culture and values. Or it can engage in an uphill struggle on price and function only.

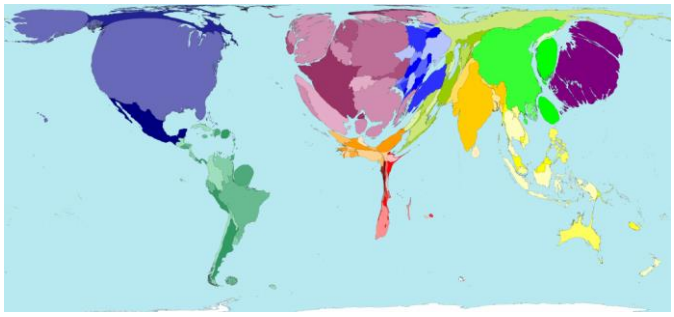
13.2.2 B – BRICs and Globalization

Brazil, India, Russia, China and others are the changing of the tides in global economic, technological, scientific, political and military power. By 2020 the EU will not be #1 economy in the world any more, but #3. It will drop from about a quarter of global GDP to less than one fifth (NIC, 2008).

Increased prosperity around the world is a good thing. This means billions more will raise out of poverty. It also means many more will have similar needs to ours. It means bigger markets like ours for products and services that we are offering already.

But it also means more competition. And not only competition to European worker, also the competition for the innovator, engineer, scientist and scholar. Since the Renaissance our capacity for cutting-edge science, innovation and creativity has been the source of our strength and wealth. The role that the EU and European countries play on the international scene is linked to the vitality of its science and innovation, strengths of its population, vibrancy of its economy and potency of its diplomacy and military. Europe's share in all those areas is likely to diminish in the future.





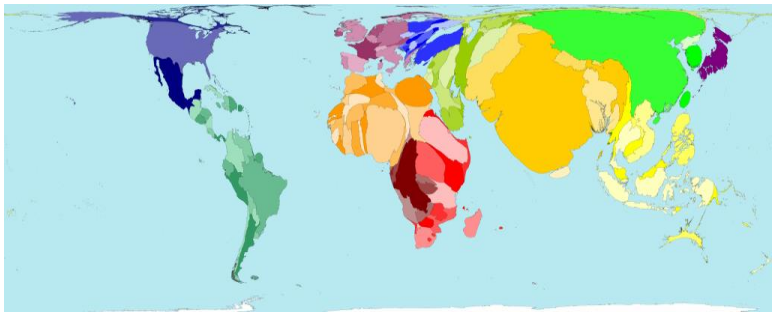


Fig. 13.1 Global GDP in 1500 (top), 1960 (middle) and talent pool in 2050 (bottom). Source: Worldmapper.org.

13.2.3 Climate Change and Energy

Current ways of using the natural resources are unsustainable. In particular the use of the atmospheric capacity to absorb and process the greenhouse gasses is most likely leading to significant warming of the planet with dire consequences for the life on it (IPCC 2007; Stern 2006). Standard of living cannot be maintained without energy and developing world cannot be deprived of the same standard that we have. The world will simply have to find a way to achieve the same quality of life by using less energy and a way to create almost all energy from renewable resources. This is a revolution, because in about 40 years we will need to replace the power base and much of the infrastructure that it took centuries to build.

Price instability of fossil fuels and concentration of supply from a few rather volatile regions is another motive for a change in energy policy.

13.2.4 Demography and Ageing

The EU is facing a major demographic challenge. The population is expected to peak at around 520 million in 2030 and then dropping back to 505 million by 2060 (Giannakouris 2008). This population will on average be much older today's, less optimistic and risk taking, while the EU will face demographically youthful societies globally and particularly on its southern and southeastern borders. By 2025 the EU, even with expected expansions, will be 6.5% of the global population (EC, 2009). With human talent becoming the main economic resource (Florida, 2005), this also gives a perspective on the global share of the EU in the tomorrow's world.

The EU can either begin again to celebrate life, children and family, work longer and allow for immigration, or face severe worsening of the relation between the working and the supported population.

13.2.5 Electronic Communication

Technological and scientific development is rapid in all areas. Amazing breakthroughs are happening in the fields of medicine, biotechnology, nanotechnology, genetics and other new sciences. But no other field has such a pervasive impact on all areas of life than information and communication technology. It is communicating among people that makes a family, enables collaboration in business, science, politics and governance. In the next decades the communication revolution around the internet will change how people collaborate, learn, work, it will change the mass media and will even have an impact on the kind of democracy and citizen participation is practiced (Turk, 2010). It is an event of the scale of invention of affordable paper and print of half a millennium ago. The digital world is global. Countries and Unions do not exist on the net. There are no borders. Anyone is a few mouse clicks away. Everyone is a few clicks away.

13.3 Global, Historic and Immediate Nature of the Disruptions

The trends are historic. Abundance of industrial products is signaling the historic shift from industrial economy to a post industrial economy creative economy where information and meaning add most value (UN, 2008). The rise of BRICS is signaling the end of the dominance of the West that lasted some 500 years. The climate change problem is, after 100 years, triggering an energy revolution, this time from below ground to above ground energy. Demographic trends are, for the first time in history, creating a pessimistic old society and opening the question if per capita growth is possible without demographic growth. The electronic communication revolution is comparable to a Gutenberg revolution 500 years ago.

The trends are fueling the economic crisis in the short term. Many of the disruptions played a part in the crisis. The rise of the BRICS after the end of the cold war created the global imbalances in trade, exchange rates and savings. The financial sector, that was the epicenter of the crisis, was responding to the desire of many for a safe old age. Because of the lack of social security system, some (like in China) were saving too much and because of its existence, some (like in Europe and the US) too little. Both stock and real estate bubbles were created by savings that did not go into real investment - into new factories, machines, infrastructures. Because the rich economies failed to introduce a new sustainable model of growth this is a crisis of the Western economies. Very high energy prices and fears of inflation stopped the availability of easy money. The crisis, when exploded, spread with the speed of the Internet and depth of panic only new media can create.

Disruptions are global, not European. Except for the demography where European problems are shared with Japan and China, the disruptions are global. Europe's problems are not global problems any more. The cold war was the last European war that became the global war. Europe's peace is not global peace. The next few years will define, if the crisis revitalized Europe or whether it will

provide the date that will be used by historians to mark the beginning of the decline of a great European civilization.

As a general response to the challenges, the Reflection Group on the Future of Europe (Gonzalez at al, 2010) presented two options to reform or to decline.

13.4 Construction and ABCDE

The related challenges and decisions of the construction industry are not as dramatic, but nevertheless important. They are addressed in the next Section.

13.4.1 Abundance

The gains of productivity that have characterized some other industries did not take place in the construction industry. In fact some studies suggest that the productivity has been stagnating since the 1970s. Although the infrastructure and the housing is abundant in the developed world, much could be improved and a substantial portion of the infrastructure needs maintenance and upgrading.

On the down side, construction is fulfilling the objective functional requirements – countering the natural forces of gravity, earthquakes, floods, heat and cold. As we have shown in the previous section, however, much of the global economy is shifting attention from function to meaning. Function is a commodity. In the built environment the "meaning" part is created by the architects and the function by the various types of engineers. There is an increasing price difference between a square meter of a facility that simply provides the function of a sheltered space and the price of a square meter of a facility that the architect made desirable. The fact that architects are getting involved in the design of bridges is also a demonstrator of this trend. What used to be a rational engineering work that provides a function – provide a dry passage over a river for example – not has to tell a story, make sense, meaning and there seems to be an agreement that only an architect can do that.

One could simplify this with the 1:10:100:1000 rule. If 1 is the cost of the structural system, 10 cost of facility, 100 cost of facility use and 1000 cost of business in that facility. The figures are illustrative and not precise; however, they invite the rethinking of any savings in the construction phase, particularly the savings in the structural system.

13.4.2 BRICS, Globalization and Construction

The real growth of the construction industry will take place in the BRIC economies. The real need and the growth are there. The effect of the globalization on the construction industry is different of we observe construction as a material industry or as an information industry. Naturally it would be classified as the first but the fact is that some construction processes are material (like actual building) but some are informational (like designing, planning). All information work is getting globalized and the construction related information processes and services will be even more globalized in the future. It makes much sense for the local

contractors, queries and concrete plants to be involved in local construction projects but he designs could actually be done anywhere.

13.4.3 Climate Change, Energy and Construction

Climate is getting warmer and the reduction of the CO2 emission will remain one of the important policy goals in the future. Construction industry is a double winner in this context. On one hand new business opportunities will be generated by the changes of the climate – constructing dams for the high seas, irrigation infrastructure, retrofitting buildings for warmer climate etc. On the other, construction will benefit from the government policies that will stimulate the greening of the economy and society: reduction of energy use in buildings, investments in public transport, renewable energy power plants etc. Most of what are regarded as low hanging fruit of the improved energy efficiency will create new business opportunities for the construction industry.

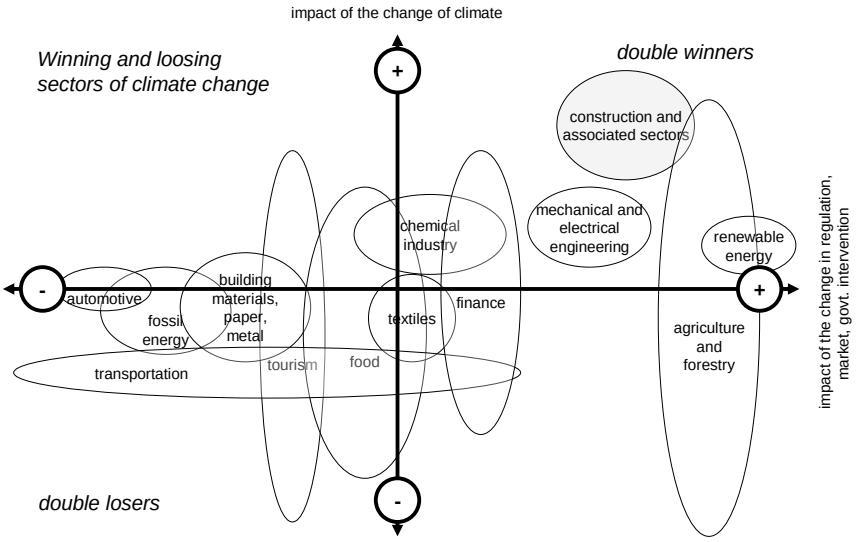


Fig. 13.1 Construction industry as a double winner in climate change. Source: Deutche Bank.

13.4.4 Demography, Ageing and Construction

If the human talent is the ultimate economic resource then economies should be involved in a competition for that talent. Florida claimed that talent is attracted by tolerance, other talent and technology. The technology not only means the IT infrastructure but the general living conditions to which a lion's share constitute the industries that shape the built environment: civil engineering, architecture and urban planning. He invented the concept of Creative City where of mix of these

three professions provide a stimulating ecosystem for the creative class and new high tech as well as other innovative startups.

13.4.5 eTechnologies and Construction

Ever since the introduction of systematic design documentation, information technology has been enabling the fragmentation and specialization of the profession. The author has studied the impact of communication revolutions on construction and claimed that (1) the communication revolution of the cheap paper that allowed for drawing and printing and (2) the digital communication revolution created three different organizational paradigms of construction (Turk 2001): the period of master builders before introduction of cheap paper, the period of local teamwork organized around the exchange of paper documentation and the period of global teamwork. The latter is organized around information sharing and collaboration on the internet. Internet will be enabling the globalization of the information processes is construction.

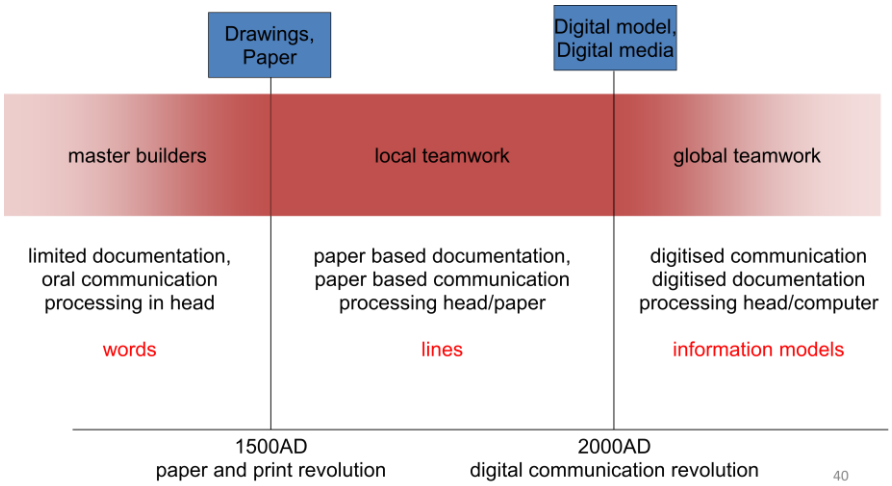


Fig. 13.1 The three paradigms of construction organization, determined by information technology (Turk, 201).

13.5 Lessons for and from Earthquake Engineering, Discussion

The earthquake engineering aspect of construction addresses perhaps the most functional aspect of buildings – making sure the structure withstands the forces of nature. Somehow humanity is taking for granted that we can outsmart nature in any are. While challenges clearly remain the investors in particular should bear in mind the 1:10:100 rule and the fact that the function is a commodity, that function is relatively a small part of today's products.

Globalization of the construction information processes may introduce new risks. The respect for earthquakes is an inherent part of the culture in areas where earthquakes happen. While designers from places where earthquakes have never been an issue may be knowledgeable about the theories and equipped with the right software the tacit and intuitive elements of their knowledge may be missing. On the bright side expertise from countries with a history of earthquakes can be more easily shared around the world.

The trends listed in Section 2 are, in spite of their disruptive nature, long term trends that are known. The unknowns that they introduce are the known unknowns. History, however, are not just trends, but also the so called Black Swan events that come as a surprise. Earthquake Engineers have been dealing with Black Swans forever and methods that have been used to abstract and model the unexpected in earthquake engineering could perhaps be reused in the sciences of forecasting of the future.

Many events in a society are exhibiting similar phenomena as in geology. For example, social scientists wonder why unrests and revolutions in a society happen apparently without a warning or why sudden crashes happen in a stock market. Studies that model pressures in a society or in financial markets could borrow from the models of pressures that are building along the geological fault lines before the energy is released by an earthquake. The potential strength of the earthquake and or the strength of the social revolution could be related to the length of the fault line – that in the earth crust or that in a society.

The financial systems could borrow the principles of the resilience of buildings against earthquakes for the building up of the resilience of the financial system. If let to itself even with good but unchanged regulation, the financial system would develop itself into a highly optimized organization that would minimize the costs and maximize the profits but would be extremely vulnerable to unexpected shocks. Much like an engineering product that is optimized for weight or speed is not very resilient. Earthquake engineers know how to build resilient, time proof structures. The designers of Formula 1 cars do not. Lessons from earthquake engineering could be used to build resilience into societal and economic systems.

ABCDE are societal trends. Engineers have a role to play. They are part of the solution as innovators. Engineering problem solving method is useful because there are similarities between an engineering and political work. Both professions are dealing with incomplete information and approximate models. Both must have a holistic perspective. Civil engineers in particular should not forget that, also as the creators of civilization. They should keep in mind the statement by philosopher Martin Heidegger that “the essence of technology is nothing technical”.

13.6 Acknowledgement

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First part of this paper presents author's personal views and thoughts which may or may not overlap with the upcoming report of the Reflection Group.

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