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Global Climate Change: What Can Structural Engineers Do to Help?

Changement climatiques globaux: que peuvent faire les ingénieurs civils?

Globale Kilmaänderungen: Was können Bauingenieure tun?

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SUMMARY

By emitting carbon dioxide and other so-called greenhouse gases, mankind's industrial and agricultural activities threaten to change the global climate in unprecedented ways. Scientists believe that average temperatures may increase by 3°C by the middle of the century, causing sea-levels to rise, farmlands to dry up, and much more. Structural engineers need to be aware of these potential impacts so that they design and build projects that are able to withstand the increased stresses of tomorrow's climate. They must also emphasize designs that are extremely energy-and-water efficient.

RESUME

En émettant du bioxyde de carbone et d'autres gas provoquant l'effet de serre, les activités agricoles et industrielles de nos sociétés risquent de modifier de façon jamais vue auparavant la situation climatique globale. Des scientifiques pensent que les températures moyennes pourraient augmenter de 3°C avant le milieu du siècle prochain, entraînant entre autres l'élévation du niveau des mers et la sécheresse de régions agricoles. Les ingénieurs civils doivent être conscients de ces dangers potentiels afin de concevoir et réaliser des projets capables de résister aux effets climatiques futurs. Ils doivent aussi proposer des projets extrêmement économiques du point de vue energétique et de l'utilisation de l'eau.

ZUSAMMENFASSUNG

Durch die Emission von Kohlendioxid und anderer sogenannter Treibhausgase drohen die industriellen und landwirtschaftlichen Tätigkeiten der Menschheit das Klima in noch nie dagewesener Weise zu verändern. Nach Meinung der Wissenschaftler könnten sich bis Mitte des nächsten Jahrhunderts die Durchschnittstemperaturen um 3° C erhöhen, so dass der Meeresspiegel ansteigt, Ackerland ausdörrt und anderes mehr. Dieser möglichen Auswirkungen müssen sich Bauingenieure bewusst sein, damit die Projekte, die sie planen und bauen, den zukünftigen Klimabelastungen gewachsen sind. Insbesondere ist bei der Planung auf höchste Wirschaftlichkeit im Energie-und Wasserverbrauch zu achten.

Could you imagine building a major roadway that soon buckled and crumbled into a useless pile of rubble because the frozen ground beneath it warmed up and shifted? Or a coastal highway that had to be abandoned after 10 or 20 years because the sea kept flooding it and eroding its edges? Or how about building a city in a place that became so dry that there was no longer enough water for the people living there to bathe or cook? Or where the temperatures became so hot that the building materials you used could not handle the stress?

Surely, such fiascos could only happen to companies that are careless or guilty of poor planning. But disasters of this type will be become increasingly commonplace in the decades ahead if engineers and other professionals involved in major construction projects ignore the phenomenon of global climate change.

In the past, projects intended to last for 30 to 100 years or longer could be designed to meet the constraints of the current climate. But today this is no longer the case. Scientists now have strong evidence that the climate will change in unprecedented ways over the next 50 to 100 years. They have learned that mankind's industrial and agricultural activities are emitting carbon dioxide and other so-called greenhouse gases that are changing the way the atmosphere absorbs the sun's energy. This threatens to upset our climate's delicate balance faster and more dramatically than ever before in human history. If no action is taken to reduce greenhouse gas emissions, many of the world's societies and eco-systems may suffer devastating damage.

Is this just another exaggerated disaster scenario designed by the press and environmentalists to frighten people? No, it is not. As director of the Information Unit on Climate Change, it has been my privilege to meet and to work with some of the leading researchers in this field. Scientists are not hysterical types. In fact, they are extremely conservative, and they are used to having their work judged by the rigorous and demanding standards of their scientific colleagues. They do not pander to environmental activists or to other politically motivated groups.

Higher temperatures and sea-levels

Scientists believe that one of the main effects of mankind's emissions of carbon dioxide and other greenhouse gases will be global warming. Assuming that no action is taken to reduce emissions, computer models of the earth's climate predict that global average surface temperatures will rise by 1-3 degrees centigrade by the year 2030. This is larger and faster than any such change over the past 10,000 years. There is some evidence that this warming has already begun. Further global warming would shift climate belts towards the poles. For example, according to the global warming scenarios predicted by many models, the climate of Finland will come to resemble that of present-day northern Germany, and Iceland will experience conditions similar to Scotland's. It is less clear how warmer, semi-arid regions will be affected, but the expectation is that higher temperatures will cause more droughts and expanding desertification in many developing countries.

Clearly, rising temperatures will have a direct impact on infrastructure such as roads, buildings, and dams. For example, global warming would lead to a general melting of permafrost in Alpine and northern tundra regions, making the ground less stable for existing transport and building infrastructure. Elsewhere, higher summer temperatures would lead to increased heat stress for people as well as for physical infrastructure. In addition to higher average temperatures, global warming would cause an increased frequency of extreme events, such as heat waves. For example, the city of Washington DC currently experiences 36 days per year when the temperature exceeds 90° Fahrenheit and one day when it exceeds 100° Fahrenheit, or 33 and 38 degrees Celsius respectively. But a study by a NASA scientist concluded that if atmospheric concentrations of carbon dioxide double, then the number of days above 90°F would increase to 87, and the number of days above 100°F would increase to 12. In other words, the temperature for most of the summer would exceed 90°F, with two weeks above 100°F. How much of the existing infrastructure has been built to withstand years of such stress?

Perhaps the most dramatic result of higher temperatures will be a rise in sea-levels. Global warming would cause the sea to rise in two ways: through thermal expansion of ocean water, and by discharges of fresh water from continental ice caps and mountain glaciers. Many scientists believe that the global mean sea-level has already risen by 1-2 centimetres during the past century. Climate change is expected to cause a further rise of some 20 centimetres by the year 2030 and 65 centimetres by the year 2100. Some forecasts call for even higher sea-level rises.

Higher sea-levels would cause immense damage. Perhaps 20 centimetres doesn't seem like much, just as a 1 or 2 degree temperature rise may not sound so dramatic. But a rise in sea-level would create irreversible problems for millions of people. Some of the nations that are most at risk are small islands in the Pacific, the Indian Ocean, and the Caribbean -- some of which may have to be completely abandoned -- as well as Bangladesh, Egypt, Gambia, India, Indonesia, Mozambique, the Netherlands, Pakistan, Senegal, Surinam, Thailand, and Vietnam. Other high-risk areas are estuaries and low-lying cities and provinces such as Sydney, Shanghai, and southern Florida.

The direct costs of rising seas would amount to hundreds of billions of US Dollars. One leading economist (William Nordhaus) has calculated that protecting coastlines from a 70-centimetre sea-rise by building dikes and other barriers would cost 618 billion dollars in terms of 1981 dollars during the next 100 years. The indirect and non-market costs of a sea-level rise would dramatically increase this figure. Indirect costs would include the loss of coastal industries such as fishing and tourism, and of buildings and other infrastructure. The costs of resettling populations and of rebuilding would also have to be considered, as would non-market costs such as social dislocation, the intrusion of salt-water into estuaries and aquifers, and the loss of biologically rich eco-systems. Economists are now trying to refine new methodologies for measuring these indirect and non-market implications.

Worsening storms and droughts

Most accounts of climate change have emphasized the outlook for hotter temperatures and higher sea-levels. But in fact these two impacts may not be the most important. Other changes, such as growing storm activity and increasing droughts and water shortages, may wreak even more damage. Scientists believe that climate change may cause hurricanes and tropical storms to increase in intensity and perhaps in frequency. Meanwhile, expanding droughts and dryness would put greater pressure on global freshwater resources. The large water requirements of households, industry, and agriculture are already creating problems in areas where water is scarce. Conflicts over water resources are likely to worsen, particularly in regions with rapid population growth.

Climate change will make water resources even more vulnerable than they are now, particularly in arid and semi-arid countries. If climate change reduces precipitation in a region, the freshwater storage reserves, primarily in the form of groundwater, will steadily shrink. An increase in extreme events such as droughts and floods, or even more modest variations in precipitation from year to year, can also seriously disrupt water supplies. Lowered fresh-water levels would require major adjustments by urban settlements located on the shores of rivers and lakes and would have an enormous impact on engineering projects -- not only on dams and other water-related projects, but on any building or project that consumes water.

These dramatic impacts -- warmer temperatures, higher sea-levels, droughts, and storms -- would clearly have social and economic repercussions. Disputes over limited or diminishing resources such as water and arable land would proliferate, both between individual countries and within them. This would put societies under greater stress. Where adjustments could not be made quickly enough, social unrest, protest movements, and political instability would probably increase. In already-fragile societies, the stress of climate change could lead to either complete social breakdown or to more authoritarian rule. If climate change has its predicted impacts, many developing countries may lack the necessary resources for protecting themselves. Social upheaval and economic crisis would strongly affect the project needs of developing countries as well as their ability to maintain and to pay for these projects.

What can be done?

So much for the likely consequences of climate change. Now, what can you, as concerned citizens and as engineering professionals, do to help minimize climate change and its impacts? Allow me to make the following proposals:

First and most importantly, reduce the use of fossil fuels by the projects that you construct. Energy from fossil fuels is believed to be responsible for about one-half of man-made climate change. In the year 1985 alone, the combustion of oil, gas, and coal released some 5.3 billion tons of carbon dioxide into the atmosphere. At current rates of per-capita emissions and world population growth, CO_2 emissions will more than double in many regions by the year 2025. To prevent this, we must make technical improvements to the composition of fossil fuels, increase our energy efficiency, and replace fossil fuels with solar energy and other energy sources that do not emit greenhouse gases. Governments may soon coax industry to reduce its fossil-fuel emissions by imposing national emissions targets, carbon taxes, and tradable emissions permits schemes. Most OECD member states have set national targets for stabilizing or reducing their emissions of greenhouse gases. In 1990, the Council of the European Communities adopted a policy that provides for stabilizing the emissions of carbon dioxide at 1990 levels by the year 2000. However, unless much more drastic efforts are made, Europe's emissions seem set to *rise* by 11%.

As shown by the dramatic recent evidence that an enormous ozone hole may be opening up over the Northern hemisphere this spring, sudden and frightening evidence that confirms climate change could come at any time. This would result in growing pressure on you to make rapid improvements in the energy-efficiency of your designs. In addition to tackling this technological challenge, you may want to support efforts to reduce emissions via reliance on carbon taxes, which would probably be the most economically efficient way to achieve this goal.

Your second contribution can be to radically raise the water efficiency of all your project designs. For example, many areas of India, the site of your last Congress, already experience dry periods that force people to make careful use of water resources. Improved water management will prove even more essential if climate change reduces the monsoons or regular rainfall. Other important steps you could take would be to support government efforts to sensitize people to the problems of water wastage and to introduce policies or taxes to constrain demand. Finally, you could support the creation of a worldwide inventory of national water resources to support water-use planning in the event that climate change has its predicted effects on water supplies.

The third way you can contribute is by planning for rising sea-levels. Don't build inappropriate projects in vulnerable areas. Meanwhile, support the efforts of coastal nations to discourage unsustainable development in coastal areas and to implement emergency preparedness and response mechanisms. Most of these measures would have numerous benefits for these countries and would be justified even if sea-levels do not rise as much as predicted. Don't forget that in addition to the havoc caused by rising sea-levels, your designs may also have to cope with other stresses, including increasing storms, droughts, and floods.

Fourth, do not allow your projects to lead to a net loss of forest cover. Although industry and energy are the leading causes of climate change, the over-exploitation of ecological resources also produces greenhouse gases. Deforestation, which over the past 25 years has lead to the loss of more than 15% of the tree cover in some countries, has a number of adverse effects on the climate. Most importantly, it releases into the atmosphere carbon that was previously sequestered in trunks and leaves, either directly through burning, or indirectly through decomposition. Deforestation also reduces evapotranspiration, particularly in rain-forests, which upsets the atmospheric water cycle on both a small and a large scale. justifications for massive deforestation in the first place.

Reforesting the earth will be critical to reducing the amount of carbon dioxide in the atmosphere. Growing 370 million hectares of new forest, an area equal to about one-half of the Amazon Basin, would absorb 17% of current annual fossil-fuel emissions of carbon dioxide. The problem is that, with a growing world population putting ever greater pressure on land resources, it is becoming increasingly difficult to set aside large tracts of forest. We must all make special efforts, then, to reverse the current trend of cutting down more trees than we plant.

So far I have outlined several ways that engineering professionals can help people to cope better with the impacts of climate change. But there is much more you can do as well. You can transfer technology to developing countries to enable them to participate in solving what is truly a global, and not merely a national problem. You can also, as other industries and professions have done, become involved in the negotiation process for a legally binding global treaty on climate change. Whether climate change proceeds quickly as some scientists believe it will or at a more moderate pace, a delay in adopting global policies to reduce greenhouse gas emissions could lead to significantly more global warming. The negotiation process began in 1990, when the United Nations established the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change (INC) to draft a legally binding climate treaty. The draft convention is to be ready for signature at the UN Conference on Environment and Development (UNCED) in June 1992. Even if we act now, it is probably too late to avoid some degree of climate change, but if governments can agree on policies to reduce greenhouse gas emissions, negative effects such as higher temperatures could be greatly reduced.

By recognizing the scientific evidence on climate change, then, the engineering profession can build infrastructure that will be suitable to tomorrow's climate and that will not prove obsolete before its time. It can also help to reduce the negative impact of human activities on the global climate, and help people to adapt to those changes that we are unable to prevent. I hope you will accept this challenge.

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