Svein Haagenrud

Durability of the Built Environment and Environmental Characterization

The built environment is in a really bad state. For many years society has been aware of that, and has been fighting against environmental degradation of the cultural heritage, which traditionally is defined as buildings and situations of historic value. However, it is not only this cultural heritage which is exposed to environmental degradation and at risk. Also, the newer built environment is under attack in just the same way. It has now become clear that after the "build and let decay" age during the last 30 years, i.e. the damage to building materials and constructions generally has become an enormous economic, cultural and environmental problem, not only in Europe, but in most developed nations as well.

The building stock and infrastructure in each country constitute more than 50 % of each country's real capital. The yearly maintenance costs amount to billions and billions of ECU per year, and should be considerably increased as Europe's building activity shifts from new-building to maintaining and care-taking of the existing. The German market alone is estimated to 2,000 billion DM towards the year 2000. An increased effort in this area also has the potential of creating millions of new jobs for Europe.

The degrading built environment also constitutes a major environmental problem in the context of sustainable development. The wasteful consumption of energy and materials linked to the degrading built environment has to be resolved.

There are a whole set of reasons for this bad state of the built environment, ranging from the market-closed society of public administration and conservators/scientists in the cultural heritage area, to the lack of recognition of the importance of service life and maintenance of the more modern buildings. Main barriers for a proper care-taking and maintenance of the built environment are:

- No total life cycle concept exists for buildings.
- Lack of main contractor responsibility, sub-contracting dilutes responsibility, and hinders major developments.
- Poor workmanship and inadequate quality control dominates.
- The very fragmented R&D in this area, resulting in duplication of basic research, low technology and little application and market orientation.
- Lack of standards and regulations.
- Lack of communication between material scientists and designers, engineers and contractors.

The EUREKA umbrella EUROCARE

deals with all these problems. EUROCARE started out in 1986. As a EUREKA Umbrella it aims at facilitating and promoting market oriented EUREKA projects, which should counter-act the degradation of Europe's built environment, including the cultural heritage and within a sustainable development context. The long term strategic goal of these projects is to increase the service life of the built environment and decrease the yearly life cycle cost for its conservation, restoration and maintenance.

18 of the EUREKA countries and CEC are now members of the EUROCARE umbrella, comprising a network of more than 350 organisations and a project portfolio of more than 40 EUREKA projects.

To facilitate and promote EUREKA projects, the EUROCARE umbrella has important tasks, such as:

- Serving as a market developer and integrator of R&D
- Offering supportive measures in standardization and funding
- Monitoring of project portfolio
- Work to increase synergy and interaction with CEC.

Important achievements have been reached in all these areas, as for example on integrating R&D:

To safeguard our built environment, action is urgently needed. In principle there are two possibilities – and both should be pursued in parallel. First, society should try to improve the environment surrounding the materials, and secondary, better products, processes, infrastructures, methods and standards should be pursued.

The second issue is EUROCARE's main concern, while the first is being pursued by the environmental research area via cost-benefit analysis for material corrosion.

Knowledge about the exposure environment and its relationship with the degradation of various building materials (dose-response and damage functions) is very much needed both in the environmental research area as a basis for policy decisions on abatement strategies, and as well in the building and construction sector as a basis for proper maintenance and service life planning.

Environmental cost benefit analysis of building materials degradation

Environmental cost benefit analysis for various themes, such as health, forest, materials, are needed as basis for policy decisions on abatement strategies. A building inventory, MOBAK (Kucera et al., 1993), gave ground for detailed analysis in Stockholm, Sarpsborg and Prague. An extrapolation of this model for Europe showed a benefit of about 10 billion dollars per year in savings by implementation of the 2nd sulphur protocol (Cowell and ApSimon, 1994).

Long-term research in the environmental area has substantially improved the basis for methods and data for proper corrosion mapping and cost assessment:

- Dose-response and damage functions have been established via the UN / ECE / ICP exposure program and the MOBAK building inventory.
- Knowledge about the environmental degradation factors exist on the European level via the European Monitoring Environmental Program and UN / ECE / ICP programme, on the

regional and local level via national surveillance programs and the "Urban air" project (EEA, 1993).

– For many reasons air dispersion models play an increasingly important role in characterizing the atmospheric environment. This is the case also as concerns exposure to the built environment. However, for maintenance planning of each specific building/object knowledge about the micro environment is of decisive importance.

– Data should be made available on user friendly geographically information systems (GIS), which collect, integrate and present data in a very useful way. The integrated environmental surveillance and information system, ENSIS, was developed and demonstrated for the Winter Olympic Games in Lillehammer. Since then, ENSIS is under further development and implementation in major Norwegian cities and abroad. ENSIS contains a number of different applications and tools for air and water quality (Haagenrud et al., 1994). Based on the needs and requirements of the user the ARCView GIS based ENSIS concept can be used to establish a tailor-made application for any user need for environmental information. In that context the new ENSIS Corrosion module has been developed.

– In the UN / ECE / ICP dose-response functions for a range of materials and mapping procedures based on "Critical/acceptable load" concept have been developed. By using these functions and procedures together with the available air quality data and dispersion models, the corrosion can be modelled and mapped via the ENSIS Corrosion module.

Service life and maintenance planning of built environment

For economic and environmental reasons there is a great need for a more durable built environment. An international standard on design life of buildings is currently in the process of being elaborated within ISO/TC59/SC3/WG9. This group was set from the joint initiative for standardization by the EUREKA umbrella project EUROCARE, and CIB/RILEM, towards CEC and CEN in 1991, and based upon the generic RILEM Recommendation for prediction of service life. In Europe the entry into force of the Construction Products Directive (CPD) also creates an urgent and increased need for standards addressing the issue of durability. For industry to respond to the standards and requirements, a lot of data and knowledge needs to be compiled or generated.

As shown above, the data could be supplied or provided for through extensive co-operation with meteorological and environmental research organizations.

Mapping of the corrosion rates can easily be transformed into maps for service life and maintenance intervals if the performance requirement is defined for the material in question. It could then serve as a tool for maintenance planning for individual users etc. In this respect the question of transformation and validation of these dose-response functions to the micro environment on the building surface has to be addressed.

Some classification systems for materials exist, such as Scheffer's index for degradation of wood and the ISO 9223-26 Classification of atmospheric corrosivity for metals. These concepts are powerful tools in assessing environmental aggressivity towards building materials. Their application, however, is and will be dependent on the availability of data and user friendly systems for its use.

Conclusions

Users of materials performance data can achieve all the needed environmental data by collaboration with the environmental research area. Such a collaboration should also have the mutual benefit of establishing much more sound cost benefit data for the degradation and maintenance of Europe's built environment. This is a very much needed documentation that should serve as basis for a more comprehensive market-oriented and strengthening effort on the maintaining of Europe's built environment.

References

Cowell, D.; ApSimon, H.: "Estimating the Cost of Damage to Buildings by Acidifying Atmospheric Pollution in Europe." In: UN/ECE Workshop on Economic Evaluation of Damage caused by Acidifying Pollutants, London, May 1994.

EEA Task Force, DGXI, CEC: Europe's environment – The Dobris Assessment. Prepared by the European Environment Agency Task Force (European Commission: DG XI and Phare). Eds. D. Stanners, P. Bourdeau. European Environment Agency, Copenhagen 1995.

Haagenrud, S.E., Henriksen, J.F. and Skancke, T.: "Mapping of urban material degradation from available data. At Acid Rain '95 Conference, Gothenburg, 1995." In: Special Volume of Journal of Water, Air and Soil Pollution, 1995.

Haagenrud, S.E.; Sannerhaugen, V.; Støve, J.; Dufseth, H.; Bøhler, T.; Aasgaard, G.F.: EUREKA-prosjektet EU 833 ENSIS '94 - Sluttrapport; Sammendrag og konklusjoner og Sluttrapport; Teknisk del. Kjeller (NILU OR 52/94 og OR 55/94) (in Norwegian).

Kucera, V.; Henriksen, J.; Knotkova, D.; Sjöström, Ch.: "Model for calculations of corrosion cost caused by air pollution and its application in three cities." In: Progress in the understanding and prevention of corrosion, 10th European Corrosion Congress, Barcelona, July 1993 (A). Eds. J. M. Costa, A. D. Mercer. London, Institute of Materials. Vol. 1, pp. 24-32.