LCA IN CONSTRUCTION WORKS AS A POWERFUL DECISION MAKING TOOL. ACCIONA INFRASTRUCTURE´S EXPERTISE.

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ABSTRACT

Construction sector is aware of the need of measuring, avoiding and reducing environmental damage caused by construction materials, processes, services, construction methods and sites.

ACCIONA Infrastructure has the strategy of considering LCA as a tool for both environmental and business management. ACCIONA´s Technology & Innovation Division has applied LCA methodology to building and civil construction. ACCIONA bets on innovative materials and construction processes which help to reduce environmental impacts by replacing traditional ones by them. Some LCA examples highlight encouraging results for innovative materials like fiber reinforced polymers in comparison with traditional ones like concrete and steel.

In conclusion, thanks to life cycle thinking, construction sector has enhanced its processes and products, making them more technically efficient and environmentally sustainable.

INTRODUCTION

The global understanding that natural resources and non-renewable energy sources are not inexhaustible has been growing lately together with the increase of conscientiousness on the consequences that our demanding way of life has on the environment. Global warming, ozone layer depletion, greenhouse effect or acid rain, are some of these consequences, which may reach catastrophic levels if nothing is done to emend the current situation. Lately, society is beginning to consider sustainability not only as a requirement but also as a distinctive value which has to be pursued by the different areas of society such as public administration, companies, engineers and researchers (García, 2011).

As a fundamental part of society, infrastructure and building have utmost importance in sustainable development. Building sector, including housing, constitutes 30–40% of the society's total energy demand and approximately 44% of the total material use (Erlandsson & Borg, 2003). The environmental impact of construction, green buildings, designing of recycling and eco-labeling of building materials have captured the attention of building professionals across the world. Building performance is now a major concern of professionals in the building industry and environmental building performance assessment has emerged as one of the major issues in sustainable construction (Ding, 2008). It is essential making an effort to use all the available tools to apply the best structural design which not only meets technical requirements but also has a good performance to the environment. There is a concern about how to improve construction practices in order to minimize their detrimental effects on the natural environment.

In this context, environmental assessment methodologies provide a valuable tool for helping decision makers and engineers to identify and select the best alternative design regarding environmental issues. It is important to count on a common basis as well as to establish homogeneous criteria with a systematic methodology in order to obtain reliable results to compare alternatives and make right decisions. Designers of buildings, manufacturers of construction products, users of buildings and others actives in the building sector are increasingly demanding information that will enable them to make decisions that will minimize the adverse environmental impacts of buildings and construction assets. They are joining forces to develop a standard and harmonized procedure of reduction and measurement of emissions as well as common and updated databases for using worldwide.

The objective of this paper is presenting ACCIONA´s commitment in its struggle to include sustainability concept into its works and services. ACCIONA mainly uses LCA methodology as a selection criterion in order to make the optimum decision in regard construction technologies, processes and materials with better environmental performance.

METHODS

Life cycle assessment is a methodology to assess the environmental aspects and potential impacts associated with a product, process, or service considering a "cradle-to-grave" approach which begins with the gathering of raw materials from the earth to create the product and ends at the point when all materials are returned to the earth. LCA is a standardized technique (ISO 14040-44) which consists of compiling an inventory of relevant energy consumption and raw material, evaluating the environmental impacts associated with identified inputs and interpreting the results to help decision making process.

LCA becomes an environmental strategy of ACCIONA´s Technology & Innovation Division in accordance with the business line of ACCIONA Infrastructure with the aim of reducing environmental damage as well as generating business value by lowering costs associated with energy consumption and materials. Therefore, it is a tool for both environmental and business management. The main advantage of the proposed methodology is the possibility of assessing the environmental impacts and sustainability of any innovative construction process developed by ACCIONA, and the comparison of its associated environmental impacts with those caused by conventional technologies, processes or materials. ACCIONA has the know-how for applying this methodology to their decisions making processes, helped by GaBi 6.0 software (databases: ELCD, Ecoinvent, PE, updated in 2012). Some examples are LCA of several elements of buildings such as fences, pipes, floors, walls, doors and insulation panels. LCA of civil works such as a Fiber Reinforced Polymer (FRP) bridge (M-111 highway, Madrid, Spain and its comparison with its analogue structure in concrete and steel), railway bridge (Arroyo Valchano, Orense, Spain), excavation and sustaining of a tunnel in a 40MPa rock considering two different procedures, drilling and blasting, roads (Cieza-Fuente de la Higuera Road, Valencia, Spain and N-340 Road, Elche, Alicante, Spain) and structural reinforcement (with concrete, steel or FRP) of beams and columns, among others.

RESULTS

Thanks to the application of LCA methodology it is possible to obtain quantified results regarding not only general emissions (to air, water, soil) of heavy metals, inorganic and organic compounds, particles, radioactive compounds but also the eco-profile (damage caused to human health and ecosystem quality) by adding emission effects to different impact categories (CML 2001 methodology).

Results obtained after applying LCA methodology to a bridge construction will be analyzed below. The goal is the evaluation of the environmental damage caused by the construction of a 30m span and 12m width bridge, comparing the environmental behavior of a FRP bridge and a concrete bridge. Concrete bridge was made with prefabricated concrete troughs beams, precast concrete pre-slabs, steel bars and a concrete slab. FRP Bridge was made with FRP beams (infusion process), glass fiber pre-slabs (pultrusion method), a concrete slab, glass fibers bars (pultrusion method) and glass fiber upper flange (infusion process). Figure 1 details the results related to general emissions (A), emissions to air (B), CO_2 emissions to air (C) and impact categories according to CML methodology (D).

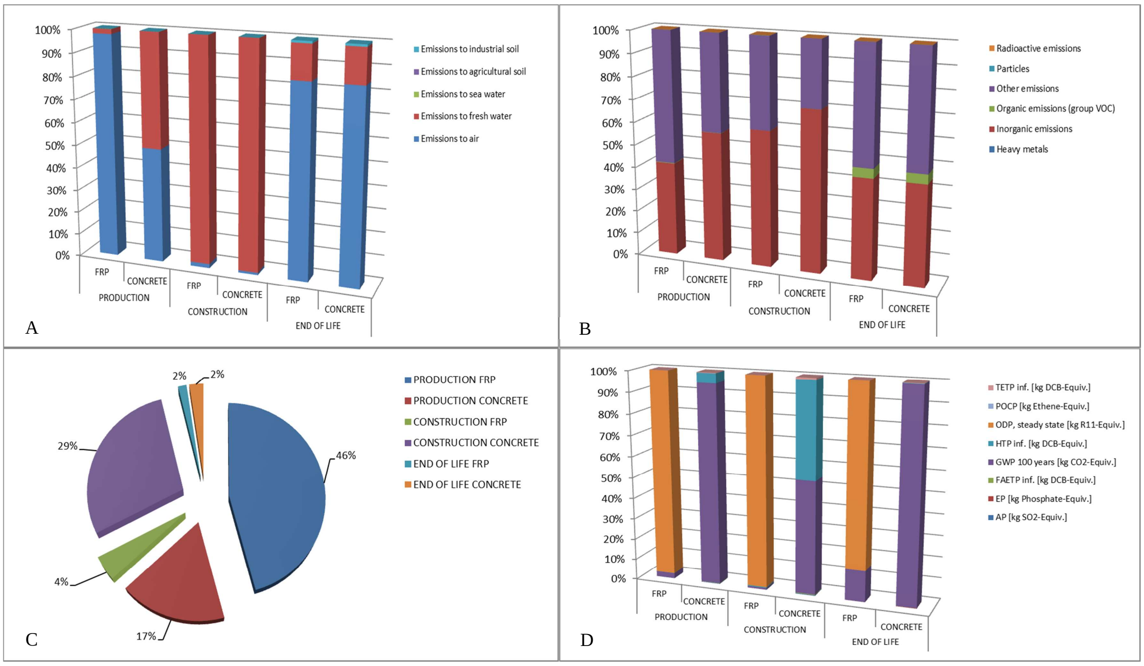

Figure 1. LCA results of a bridge. Comparison between concrete and FRP bridge.

Taking all the results into account it is possible to highlight that regarding general emissions (Figure 1_A), emissions to air and fresh water are the most generated ones during the production and the end of life stages of both types of bridges. During the construction phases, emissions to water are the most released emissions. On average, the construction of concrete bridge is the stage which causes more quantity of emissions to air, water and soil. Moreover, related to emissions to air (Figure 1_B), the highest percentage of emisions to air are caused during the production phase. In particular, the production of raw materials used in FRP bridge is the critical point because of the presence of epoxy resin as well as carbon and glass fibers. Furthermore, inorganic compounds are the most harmful emissions to air in all stages of the life cycle of both bridges, highlighting CO_2 emissions as the most generated. Specifically, the biggest quantity of CO_2 emissions (Figure 1_C) are caused during the production of FPR raw materials (resins and fibers) and during the concrete bridge construction phase. In addition, according to CML 2001 methodology (Figure 1_D), Global Warming Potential, GWP (in all stages of FRP bridge life cycle) and Ozone Depletion Potential, ODP (in all stages of concrete bridge life cycle) are the most harmful impacts to the ecosystem quality and human health. Ecotoxicity is the most generated impact to ecosystem quality during the entire life cycle of both analysed bridges. Human health is affected mainly by respiratory problems caused during the production and construction phases in both cases. Nevertheless, during the end of life phase, GWP is the most damaging impact to human health in both FRP and concrete bridges.

DISCUSSION

LCA methodology applied to a bridge construction is just one of the studies developed by ACCIONA which emphasizes the importance of this method to make strategic decisions. According to the results, considering the “cradle to grave” approach, FRP bridge presents a better environmental behavior than the concrete bridge. The main reasons are the composite lightness, which enables the reduction of fuel and energy consumptions (including transports and installation activities) as well as its excellent mechanical properties which avoid maintenance and reparation activities over the years. In general, the production phase is the most harmful stage. Specifically, the manufacturing of the required raw material for construction of FRP bridge (epoxy resin and fibers). Impacts associated to this stage could be reduced applying new and more efficient manufacturing processes or technologies, even substituting the most harmful raw materials for others. Moreover, emissions and impacts caused during the construction and the end of life stages could be also mitigated by enhancing any construction processes (lamination, infusion, pultrusion, curing, etc) and by developing more efficient and greener end of life strategies, for instance, recycling of composite.

CONCLUSIONS

It is essential to mention the importance of LCA methodology as a key tool for helping to make right decisions related to the development of any new technology, process or product considering environmental performances. ACCIONA is aware of the environmental impact of its construction methods and sites and uses LCA methodology for assessing, measuring and reducing them. This paper shows an example of how ACCIONA uses LCA method to evaluate which stage of the life cycle of a product/process is susceptible to changes or improvements for increasing the sustainability of the overall process, hence achieving the optimum technology from both technical and environmental point of view.

REFERENCES

Ding, Grace K.C. (2008). Sustainable construction- The role of environmental assessment tools. *Journal of environmental management, 86, 3, 451 -464.*

Erlandsson, M. & Borg, M. (2003). Generic LCA-methodology applicable for buildings, constructions and operation services—today practice and development needs. *Building and Environment, 38,7, 919 -938.*

García, L. (2011). Life Cycle Assessment of railway bridges. Developing a LCA tool for evaluating Railway Bridges. *Master Thesis 323. Structural Design and* Bridges*. ISSN 1103.4297. ISRN KTH/BKN/EX-323-SE.*