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# Sustainability of Ultra High strength Reactive Powder Concrete

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**Abstract:—**This paper addresses the economic cost of loss of durability in major concrete structure including the cost over the service life of maintenance and repair. It introduces the concept that the direct and indirect cost of impeded access for repair and of interruptions to services must also be recognized. (UHPRPC) can be examined in regards to its cost Effectiveness and sustainability .It is the intention of this paper to provide a qualitative statement on the behavior of normal and high strength concrete serves as a comparison The relevant Economic advantages of the (UHPRPC) is obvious regarding the life cycle which exceeds the construction process of a building Because of the smaller cross section of the column and beams being necessary now with the same load bearing capacity , the usable floor space can be increased and use of (UHPRPC) can be justified looking to the performance, cost Effectiveness and sustainability (UHPRPC) technology can be promoted in India.

**Keywords:—**Reactive powder concrete, sustainability, cost effectiveness, life cycle cost.

## I. INTRODUCTION

Reactive powder concrete is a generic name for a class of ultra high strength cementitious composites. The production of very high strength concrete, maintenance and repair of structure and life cycle cost of structure plays and important role in its cost effectiveness and sustainability of Ultra High Performance Reactive Powder concrete (UHPRPC)
n the design, planning and construction of buildings the principle of cost-effectiveness has Long been one of the principal demands made of civil engineers. Since the couple of decades this demand has been extended further and further to include the increasingly widespread social Requirement of Sustainability. While the cost-effectiveness factor is concerned purely with Economic optimization, the principal concern of sustainability also embraces ecological and social factors. Cost-effectiveness and sustainability are by no means mutually exclusive. On The contrary, cost-effectiveness is an integral component of the concept of sustainability. Among the ecological objectives that aim at more sustainability are the minimal uses of non renewable resources, the guarantee of renewable resource regeneration and the Minimization of environmental impact from waste disposal and residues. In view of the Fact that construction produces approx. 70% of all material-flow in Indian Sinerio, it is Understandable that sustainability must be one of its particular concerns in order to achieve a Higher Success rate in Sustainability objectives. Accordingly, the decision as to which Materials are to be used for the construction project is particularly important. The increasing demand for sustainability in construction invariably extends the time frame which has to be analyzed. In addition to the classical life-cycle of the structure, a Comprehensive sustainability analysis has to take account of the production process of Building materials as the waste disposal after demolition. The aim of this paper is to make a qualitative statement about the behavior of (UHPRPC) with regard to sustainability. A comparison will be made between the behavior of (UHPRPC) and normal and high-strength concrete.

## II. ENERGY AND RAW MATERIAL CONSUMPTION (UHPRPC)

The energy and raw material consumption shown in **tab.1** associated with the operational use of (UHPRPC) is investigated by means of a design example for a compound unit [1] subjected to high Pressure On this basis the energy and raw material consumption together with building material Requirement per m³ of concrete are investigated [1] for concretes of strength classes M 40/50and M 80/95 as well as for (UHPRPC) with cylinder compressive strength of 180 N / mm².

| Concrete grade | | M40/50 | M80/95 | M180 |
|---|---|---|---|---|
| Cement content | Kg/m3 | 370 | 490 | 760 |
| Aggregate content | Kg/m3 | 1866 | 1642 | 1521 |
| Steel fiber | Kg/m3 | - | - | 194 |
| Energy consumption | MJ/m3 | 1992 | 2525 | 5855 |
| Raw material consumption | Kg/m3 | 2421 | 2377 | 3903 |
| Bldg. material Requirement | Kg/m3 | 2236 | 2132 | 2475 |

**Table- 1. Energy & Raw Material consumption per M3 Source [1]**

It is clear from **tab.1** that energy consumption, in particular, increases considerably the higher the compressive strength of the concrete. Among the reasons for this are the higher cement content and the necessary addition of steel fibers at a volume of 2.0 Vol.-% in M 180 [1]. But no conclusions about the degree to which the sustainability requirement is satisfied can be drawn from this. This only becomes possible from the design example carried out in literature. A 3.50 m high reinforced concrete column with square cross-section is designed for design load. The reinforcement content $\mu$ amounts to 4 %. For concrete strength class M 40/50 these specifications produce a lateral length of 1.00 m and thus a column cross section

Of 1.00 m² If the design load and the reinforcement degree are retained, a required lateral length of 0.82m (column cross-section = 0.67 m²) for concrete strength class M 80/95 is obtained. If M 180 is used, the required lateral length is reduced to 0.66 m (column Cross-section = 0.44 m²). The energy and raw material consumption for reinforced concrete columns according to Concrete strength class at equal load bearing is shown in **tab. 2**. It is clearly recognizable that UHPC best satisfies sustainability requirements. Energy consumption for the column falls with the use of M 180, compared with M 40/50, by approx. 26 %, raw material consumption by as much as 42 %. (UHPRPC) thus demonstrates the best results vis-à-vis the ecological Objective "minimization of use of non-renewable resources". Furthermore, environmental Impact through building waste in the event of demolition at the end of the building's life-cycle
Is minimized as a result of the leaner compound units dimensions that are possible.

It should be noted in this example that energy and raw material consumption in (UHPRPC) might be reduced significantly still further below the values of M80/95, if it were possible to reduce the necessary content of steel fibers in the concrete mixture.

| Concrete grade | | M 40/50 | M 80/95 | M 180 |
|---|---|---|---|---|
| Cross –section of column | M2 | 1.0 | 067 | 0.44 |
| Volume of column, H-3.5M | M3 | 3360 | 2258 | 1464 |
| Reinforcement Steel Area | CM2 | 400 | 270 | 174 |
| Reinforcement Steel Volume | CM3 | .014 | 0.095 | 0.061 |
| Reinforcement Steel weight | T | 1.08 | 0.74 | 0.47 |
| Energy Consumption | | | | |
| Concrete | MJ | 6693 | 5701 | 8616 |
| Reinforcement steel | MJ | 1175 | 8048 | 5111 |
| Total | MJ | 18438 | 13748 | 13727 |
| Raw Material Consumption | | | | |
| Concrete | MJ | 8.13 | 5.37 | 5.71 |
| Reinforcement steel | MJ | 6.91 | 4.74 | 3.01 |
| Total | MJ | 15.04 | 10.11 | 8.72 |

**Table- 2 Energy & Raw Material consumption for compound unit of same capacity and dimensions. Source [1]**

## III. COST- BENEFITS THROUGH INCREASED FLOOR SPACE

After consideration of the ecological concerns the economic benefits of the use of (UHPRPC) this too, will be done by means of the columns considered above. If one
Compares the net production costs, the higher costs per m³ of concrete with increasing
Compressive strength, including expenditure on additional quality assurance measures,
Expert reports and special licenses necessitated by the use of non-standard concrete are
Offset by lower costs in respect of Lower quantities of concrete, reinforcement, & of formwork these result in a reduction of materials, wages, transport costs, and the necessary lifting and Moving capacities (cranes, concrete pumps) on the building site. This is true not only of the Columns considered. Because of the reduced compound unit measurements the load Assumptions for the design of the foundation are reduced. Thus, here too there are Possibilities for cost reductions similar to those for the columns mentioned above. In view of a possible reduction in foundation measurements, there may also be lower excavation costs As a result of reduced excavated material. Quantitative comparison of production costs in Individual cases must take into account current market prices. (UHPRPC) proves to be economically beneficial in terms of both production costs and the utilization phase. The smaller columns cross-section necessary with the same load-bearing capacity increases the rentable floor space. This means that the column made of M 40/50 would have to cost less by this amount in order to compensate for the multiple yields because of the increase in usable floor space.And this in consideration of the above-mentioned reasons for additional costs. Estimating the current market price for a column of M 40/50 in the worst possible scenario, the column made of M 180 would have to be a maximum of 1.7 times more expensive in order not to be offset by the advantages of the increased floor Space. On the basis of this result, the economic advantage of (UHPRPC) as compared with Normal strength concrete is clearly shown, by the example provided.

## IV. ECONOMIC ASPECTS WITH RESPECT TO THE LIFE-CYCLE COSTS OF A STRUCTURE

In addition to the production costs, the costs incurred during the life-cycle of a structure also have to be assessed in terms of cost-effectiveness. These include the repair and Maintenance costs to keep the structure functional as well as the costs incurred by Demolition at the end of the life-cycle of the structure. Together with the production costs they make up the sum total of the life-cycle costs. Investigations carried out in Austria reveal that the average Replacement costs for the raw bearing structure of a bridge that had reached the end of its Life-cycle with a effective span of up to 40 m were approx. 640 $/m² of bridge area. The Costs for repair of the bearing structure thus amount to 28 % of this value.

In order to be able to evaluate alternative construction designs with respect to their life-cycle Costs for a cost-effectiveness comparison, use has to be made of the present value method. By means of this method all costs to be incurred in the future are discounted to the Current time of consideration. The present value thus specifies the amount which has to be invested at the time of consideration, and then has to produce interest in order to be able to settle all future costs. The above-mentioned cost analysis helps to show how large the present value is in terms of New building costs, in order to clarify its importance for a cost-effectiveness evaluation of a Construction design On the long-term behavior of (UHPRPC) in practice and the resulting maintenance and repair costs, the shortage of actual buildings using it means that the existing data is insufficiently Comprehensive. Thus, no comparative present value calculation for bearing structures of Normal-strength concrete and (UHPRPC) can be made at present. Available research results, however, show that (UHPRPC) displays greater frost / de-icing salt resistance, lower rate of Carbonization progress and greater chloride resistance compared with normal- and high strength Concrete. It can therefore be concluded that structures from (UHPRPC) will also show comparatively lower maintenance and repair costs in future. Accordingly, research is needed to gather the appropriate data and experience values.

## V. 5 COST OF LOSS OF DURABILITY OF STRUCTURE.

The cost of maintenance and repair or replacement, plus the costs of obtaining access to the repair zone and the costs of interruption to services. This interruption to services is especially critical in the case of transportation structures such as bridges and Tunnels, since the volume of traffic grows exponentially through the years and there often no fully acceptable alternative Routes, much work must be carried out in the night time or on weekends often in limited areas at a time. The maintenance and repair cost in power and industrial plants are rendered very costly by the difficulty of access, which often increase through time as equipment is added.

The decision to provide increased durability ,that is to take steps on incur increased first costs to prevent various forms by which the structure can be degraded ,should there for be based on a comparison with the present value of the costs of future maintenance and repair plus the costs of access and interruption to services . High durability performance of RPC will reduce the cost of maintenance, repair, access and interruption.

## VI. CONCLUSIONS

Increasing social demand for sustainability in construction requires an appropriate Engineering evaluation of (UHPRPC). By means of a design example the lower energy and raw Materials consumption of (UHPRPC) required for a column is compared with that of normal and high-strength concrete. This shows the relatively high degree of success in achieving the Ecological goal of Sustainability. The economic benefits are shown by citing the example of the increase in floor space that can be achieved in a building, as a result of smaller Compound units. There is also the factor of the optimized durability of (UHPRPC), which generates altogether lower life-cycle costs than the existing standard concretes. In short, (UHPRPC) can be characterized as the more sustainable building material for special structures. The above-mentioned considerations make clear for sustainability of (UHPRPC). It shows, not only the net construction costs, but also the total life-cycle costs and yields are taken into consideration, then it becomes clear why, in practice, the utilization period is increasingly included in the Period of validity of construction contracts. The building contractors, in these cases, are also liable for functional maintenance and optimizing the maintenance costs of the building during the utilization. Evidence of this development can be found in new contract models drawn up by public bodies in infrastructure projects, "(BOT) -Build Operate and Transfer" This underlines the fact that the construction industry will, in future, be increasingly faced with more extensive and more complex social demands. The emphasis is much more on sustainable solutions to the construction problems by possible practical use of (UHPRPC), and Benefiting the society

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