学　位　論　文　内　容　の　要　旨

DISSERTATION ABSTRACT

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Behavior of interface between concrete-PCM at elevated temperature at material and member level

(高温下の材料および部材レベルでのコンクリートと PCM との付着界面挙動)

Strengthening, retrofitting, upgrading and rehabilitation of ageing infrastructure by Polymer Cement Mortar (PCM) is one of viable, economical and environment friendly solutions. Although PCM has superior properties than ordinary mortar in terms of mechanical strength, durability and good adhesive strength with concrete, the weakest zone in the concrete-PCM specimen is the interfacial zone. PCM after placing over treated substrate concrete surface is properly cured and after designed curing period, composite specimens/structures were exposed to severe environmental deterioration mechanisms. This fact causes the degradation of interface more rapidly than constituent materials and is responsible for significant reduction of intended service life of repaired structures. Therefore, it is necessary to investigate the behavior of interface under severe environmental conditions, which can be used for designing of repaired structures. For such aim, detailed experimental and analytical study were conducted, in which influence of moisture and temperature were investigated on composite specimens along with the constituents.

Primary goal of this work is to strengthening of concrete structure in hot regions, where temperature increases to higher than 60 ℃ in peak summer. So environmental conditions were selected, which have resemblance to real environment. Day night variation and seasonal variation with short and long temperature duration were considered as exposure conditions. PCM and composite specimens were exposed to such conditions and were tested for interfacial tensile strength at designed conditions. Polymers from PCM were extracted after conducting interfacial split tensile strength test and tested for molecular weight, glass transition temperature and melting point. It was observed that testing condition significantly affected the tensile strength of PCM and composite specimens. Severe degradation at high temperature and recovery under lowering temperature were observed. Short temperature duration, about 16 hours, is long enough to have pronounced effect on tensile strength. Maximum reduction in tensile strength was observed under the combined action of temperature and moisture and tested at high temperature. Failure mode of composite specimen was shifted from adhesive interface failure to cohesive PCM at elevated temperature, which is considered as the indication of degradation of PCM. Whereas, molecular weight, glass transition temperature and melting point of polymers were still almost the same after different exposures.

Because of the observed severe influence of moisture and temperature on interfacial tensile strength, more detailed experiments were designed, in which properties of bulk specimens and composite specimens were investigated under moisture and temperature variation separately and then combined vari-

ation. Tensile strength of concrete, PCM and concrete-PCM specimens was decreased with increase in temperature and moisture have only marginal effect. Degradation in tensile strength of PCM was significant at elevated temperature. Prediction formula of interfacial tensile strength was also proposed which was the function of the tensile strength of constituent materials and applicable for the temperature range from 20 ℃ to 60 ℃. Failure mode of all composite specimens under both types of environmental conditions was adhesive interface failure.

To increase the interfacial strength, interfacial zone was enhanced by adding primer at interface and also by increasing the roughness level of substrate concrete surface. Along with interfacial tensile strength of bulk and composite specimens at elevated temperature, interfacial shear strength was also investigated for both types of specimens. Prediction formula of interfacial tensile strength was verified by incorporating the effect of primer and enhanced surface treatment. All data lies within ±10% of experimental results when compared with the predicted interfacial tensile strength. Prediction formula of interfacial shear strength was also proposed and applicable for temperature range of 20 ℃ to 60 ℃. Small variation was observed but average experimental data lies within ±10% of predicted results, which verifies the applicability of proposed formula.

For real application of the current work, behavior of interface was also investigated at member level by conducting loading test of RC beams strengthened by PCM overlaying with different amount of reinforcement. All beams, strengthened and unstrengthened, were exposed to different temperature levels and tested at exposed temperature and humidity condition in four points loading test. Failure load of all strengthened beams were observed more than the unstrengthened beams but decreased with the increase in temperature level. Failure mode at elevated temperature was also varied from classical failure mode of conventional RC beam to debonding at overlay end as increase in the amount of reinforcement. Ductility, first crack load, yield load and ultimate load also decreased with the increase in temperature. Prediction model for debonding strength was proposed by incorporating interfacial tensile and shear strength of composite specimens, which were investigated at material level. Truss analogy approach was used for prediction of ultimate shear load and failure mode for overlay beams and close agreement was observed at all temperature levels. Serviceability of strengthened RC beams at elevated temperature was also investigated by investigating flexural crack spacing in constant moment zone at different temperature level and by measuring crack width at temperature level of 20 and 40 ℃. Crack spacing and crack width was increased with the increase in temperature.