Summary

Title: Impact of drying on the structural performance of reinforced concrete slab members/ 鉄筋コンクリートスラブ部材の構造性能に及ぼす乾燥の影響

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This study deals with the performance of concrete structures over the long term. The reinforced concrete structures are designed and constructed to perform for several decades are susceptible to degradation that cannot be avoided over such a long period. The degradation in concrete structures in the long-term is usually perceived in the form of corrosion of reinforcing bars, cracks in the concrete due to several reasons, deformations, etc. The concrete structures are subjected to non-uniform volume changes due to various reasons mostly drying. The drying of concrete results in shrinkage and restraints to the shrinkage results in cracks.

A detailed survey of available literature was carried out focusing on the drying of cement paste, mortars, and concrete. The studies show that due to drying cement paste shrinks resulting in densification. The shrinkage is governed by surface energy, capillary action, disjoining pressure, alteration of calcium-silicate-hydrate, etc. though the mechanism is still under discussion with consensus on few points. The impact of drying is observed in form of changes in the strength of cement paste, mortar, and concrete along with the development of cracks. Some research presented the decrease in young's modulus over a long period of drying. The cracks in a concrete structure are developed due to restraints to shrinkage that can be internal (due to aggregates, non-uniform shrinkage) or external (rebars, structural members). Studies reflected a decrease in the stiffness of reinforced concrete members such as columns, beams, walls, etc. Some research shows change in the yielding curvature of reinforced concrete members due to drying but some do not. Due to shrinkage and restraints, the concrete is in tension and reinforcements are in compression.

To get the set objective, first, an experimental study was conducted involving identical specimens of beams with slabs with the only difference being the curing conditions. The first specimen was tested as a fresh specimen or control specimen. The second specimen was tested after about a year of drying the specimen in laboratory conditions when it reached its shrinkage equilibrium. During the drying period, the specimen was closely monitored with the impact of drying recorded in terms of shrinkage strains and shrinkage cracks. The test results reveal that the composite structure's ultimate performances are governed by the component of highest dominance. As for the specimens tested, overall performance was defined by large beams used in

the specimen because the contribution of the large beam in terms of stiffness and moment capacity was highest. The yielding of the specimens is defined by the first yield of large beams at a drift of about 1 to 1.2%. Comparison of the test results of both specimens proves the decrease in the initial stiffness of the structure with age and drying. The flexural stiffness decreased by 50% due to drying. A similar magnitude of decrease in frequency has been reported in some available literature that was focused on the long-term performance of the structure. However, the overall lateral structural stiffness decreased to 77% only. The reason for a smaller decrease in overall lateral structural stiffness than compared to local flexural structural stiffness was that approximately half of the specimen was in tension and half in compression. The shrinkage cracks developed in the specimen render the concrete in tension ineffective to resist any tensile load while the cracks in compression tend to close leading to a fully effective cross-section in compression. Therefore, the impact of drying is observed in tension however in compression it has negligible impact. Therefore, resultant lateral structural stiffness decreased less. The occurrence of shrinkage cracks also influenced the crack distribution due to applied load with more connected and continuous cracks with a clear pattern. Cracks were mostly flexural, concentrated at the edges of the specimen which was also the critical section of the specimen with the maximum moment occurring at this place. The results obtained from the experiments were verified through sectional analysis using Response-2000. The effect of drying in the analysis is considered by ignoring the concrete in tension that is the slab of the specimen is ignored in tension. The results complied with each other proving that the drying shrinkage resulted in cracks which was the reason for slab concrete being ineffective to resist any applied load in tension. Hence the impact of drying is observed in terms of reduced effective cross-section causing the reduction in stiffness of the structures. At the yielding of the specimen, the effect of shrinkage is reduced to negligible as both the specimens yield at almost the same load and same drift resulting in similar stiffness at yield. It is considered that the residual stresses in rebar are reduced to zero due to repeated loading. the cracks developed in both specimens at yielding resulted in all concrete in tension ineffective that is, nor the effect of shrinkage cracks is observed.