

Causes and Prevention Techniques of Cracking in Cast-in-Place Concrete Floor Slabs in Building Construction

Bo Hou

CCCC First Highway Engineering Group Co., Ltd., Beijing, China

Abstract: Cast-in-place concrete floor slabs are important structural components in building engineering, and cracks are common during construction and service. Cracks may affect structural durability, waterproof performance, and building functions. Based on engineering practice, this paper analyzes the main causes of floor slab cracks from the aspects of materials, design, construction, and environmental conditions. Corresponding prevention and control measures are proposed for different influencing factors, providing a reference for improving the construction quality and crack control of cast-in-place concrete floor slabs.

Keywords: building engineering; cast-in-place concrete floor slab; crack causes; prevention and treatment techniques; construction control

1. Introduction

Cast-in-place concrete structures are widely used in building projects for their structural integrity and economy. Yet floor-slab cracking remains a frequent quality defect, driven by materials, design, construction, and environmental factors. Field statistics indicate that more than 90% of floor-slab cracks stem from temperature variation, shrinkage deformation, and construction defects, and that over 35% are harmful cracks that impair the service performance of the works. Concrete is brittle and cracks readily; harmful cracks lead to water seepage, reinforcement corrosion, and loss of load-bearing capacity. This paper therefore examines the causes of cracking and proposes corresponding preventive measures to improve construction quality and ensure structural safety.

2. Analysis of the Principal Causes of Cracking in Cast-in-Place Concrete Floor Slabs

2.1 Material factors: the underlying trigger

Substandard raw materials and poorly designed mix proportions are direct causes of floor-slab cracks. Ordinary Portland cement, the principal cementitious material, releases its hydration heat rapidly and in a concentrated burst; after casting, a large temperature difference develops between the interior and the surface of the slab, and the resulting thermal stress induces cracking. When the mud content of the aggregate exceeds 3%, bond strength and crack resistance drop markedly and shrinkage deformation increases by more than 20%. [1] Arbitrary changes to the water-binder ratio during construction, or uneven admixture dosage, likewise aggravate plastic and drying shrinkage: fine mesh-like cracks appear rapidly on the surface after the concrete hardens and gradually develop into deep cracks. Poorly graded sand and gravel aggregates and an excessive proportion of fine aggregate further increase the porosity of the concrete, reduce its compactness, and weaken the overall crack resistance of the slab.

2.2 Design factors: the inherent hazard

Unreasonable structural design predisposes floor slabs to cracking from the outset. To control cost, slab thickness is sometimes arbitrarily reduced: once the thickness of a conventional residential slab falls below 100 mm, the slab lacks the stiffness to resist loading, deflects excessively, and develops soffit cracks. Deficiencies in reinforcement design are the most serious. Excessive spacing of top negative-moment bars, low reinforcement ratios, and sparse distribution bars leave the slab without the tensile capacity to resist shrinkage and thermal stresses. Where diagonal bars and supplemental reinforcement are omitted at stress-concentration regions such as openings and internal/external corners, or where the spacing of expansion joints and post-cast strips exceeds code limits (a slab longer than 40 m without an expansion joint), local stress concentration produces regular diagonal cracks and through cracks. Some designs also ignore regional temperature differences and foundation conditions when setting parameters, further raising the cracking risk.

2.3 Construction factors: the dominant cause

Non-standard construction practice is the leading cause of floor-slab cracks, accounting for 35% of cases, and directly affects slab quality. (1) Placing defects: insufficient vibration entraps bubbles and voids and reduces compactness, while excessive vibration drives the aggregate down and floats the mortar up, forming a weak surface layer and cracking through differential shrinkage. (2) Reinforcement placement deviations: negative-moment bars displaced by trampling and cover thicknesses below 15 mm reduce the effective depth of the reinforcement and lower the flexural stiffness of the slab by 12%–18%, so cracks appear readily at the supports. (3) Improper formwork and striking control: insufficient stiffness of the shoring system or differential settlement exceeding 5 mm produces through cracks after the slab is formed, and premature striking or early loading subjects the slab — before it attains design strength — to overload and structural cracking. (4) Absent curing management: if the concrete is not covered within 12 h of casting, surface moisture evaporates rapidly, the surface and the interior shrink unevenly, and numerous plastic shrinkage cracks form; hot, windy weather aggravates the problem[2].

2.4 Environmental and settlement factors: the external trigger

Freshly cast concrete responds to ambient temperature, humidity, and foundation settlement. Large diurnal or seasonal temperature swings subject the slab to repeated thermal expansion and contraction; once the restraint stress exceeds the tensile strength of the concrete, thermal cracks form. In dry, windy, and hot environments, rapid surface moisture loss makes the surface shrink markedly faster than the interior, and shrinkage cracks follow. Inadequate site investigation or substandard ground treatment can also cause differential settlement during service; the slab is then loaded in shear and tension and develops diagonal through cracks, which are particularly harmful and difficult to repair.

3. Prevention and Treatment Techniques for Cast-in-Place Concrete Floor Slabs

3.1 Optimizing structural design to eliminate inherent risks

Since design deficiencies are the root of structural cracking in cast-in-place slabs, improving the design parameters strengthens the overall stiffness and crack resistance of the slab at the source and forestalls cracking induced by stress concentration or insufficient stiffness; this is the primary crack-control measure. First, slab thickness must be correctly determined and must not be cut to reduce cost. Standard residential slabs shall be no thinner than 110 mm, and living-room slabs and long-span cantilevers should be thickened as structural verification requires — raising the overall flexural stiffness, limiting load-induced deflection, and preventing soffit flexural cracks at the source.

Second, refine the reinforcement system. Increasing the ratio of distribution bars strengthens the restraint on the concrete, and the spacing of top negative-moment bars should be held within 150 mm so that shrinkage never proceeds unrestrained. At stress-concentration regions such as openings and internal/external corners, diagonal supplemental bars should be added: their effective length shall be no less than 400 mm, and the supplemented cross-sectional area no less than 1.2 times the area of the bars cut off by the opening — enough to offset the concentrated stress. Finally, standardize the deformation provisions for super-long structures: where the continuous casting length exceeds 40 m, provide expansion joints 20–30 mm wide filled with polystyrene foam; space post-cast strips 30–40 m apart and seal them only after no fewer than 42 days of curing, fully releasing the early shrinkage stress of the concrete and preventing overall cracking of super-long slabs.

3.2 Strict raw-material control and mix-proportion optimization

Raw-material quality and mix-proportion design are central to limiting concrete shrinkage and preventing floor-slab cracks; inferior materials and improper proportions invite early shrinkage and thermal cracks. For cementitious materials, low-hydration-heat cements such as Portland fly-ash cement and Portland slag cement should replace ordinary high-hydration-heat Portland cement, lowering the hydration-heat peak and the through-thickness temperature gradient and thereby avoiding thermal cracks in massive and large-area slabs; the approach suits all types of floor-slab construction.

Aggregate quality directly governs the compactness and deformation behavior of concrete, so every index should be verified on site: coarse aggregate should be continuously graded (5–25 mm) hard crushed stone with a mud content no greater than 1%; fine aggregate should be entirely medium-coarse sand with a mud content no greater than 2%, with fine sand and silty sand prohibited — so that aggregate impurities neither lower the strength nor enlarge the shrinkage of the concrete[3]. The mix design should balance strength, workability, and crack resistance: on the premise of meeting the design strength, hold the water-binder ratio between 0.4 and 0.5 to limit drying shrinkage from free water. Replace part of the cement with fly ash and slag powder, and adjust the dosages of water reducers and retarders precisely to keep the slump within 160–180 mm; this improves workability and curbs plastic shrinkage cracking.

3.3 Standardizing construction practice with whole-process control

Non-standard workmanship is the principal man-made cause of slab cracking and the focus of on-site quality control. Four operations — reinforcement placement, formwork support, placing and compaction, and striking with subsequent loading — must be managed precisely throughout, preventing cracks at the source. In reinforcement control, lay dedicated walkways once the slab bars are assembled so that workers never step on the top bars, preventing bar displacement and cover violation; spot-check the cover thickness with detectors throughout construction and hold the deviation within ± 5 mm, preserving the effective depth of the reinforcement, improving the tensile and crack-resistant capacity of the slab, and preventing cracks at the supports.

A stable formwork system underpins settlement-crack prevention. Support the slab formwork on a full framing shoring system whose stiffness and capacity have been verified in advance, so that the supports neither loosen nor deform. After erection, check the surface levelness and the support settlement, limiting differential settlement to 5 mm; before casting, moisten the formwork thoroughly so that dry boards cannot draw moisture from the concrete surface and cause moisture-loss shrinkage cracking. Place the concrete layer by layer in continuous segments, each layer no thicker than 200 mm; insert the vibrators quickly and withdraw them slowly at properly spaced points, avoiding both missed vibration and over-vibration with mortar flotation. Trowel the surface a second time before initial set; this closes the plastic shrinkage voids at the surface and reduces the occurrence of fine cracks.

Striking and subsequent loading deserve equal attention. Let the strength of test cubes cured under the same conditions govern striking: the slab concrete must reach 100% of design strength before the formwork is removed, and early striking that deforms and cracks the structure is not permitted. For 7 days after striking, prohibit concentrated material stacking, heavy vehicle traffic, and any other action that overloads the slab, preventing through cracks in concrete that has not fully hardened.

3.4 Strengthening curing to avoid environmentally induced cracks

Post-construction curing is a critical process for controlling shrinkage and temperature cracks in cast-in-place concrete floor slabs. Proper curing measures can effectively mitigate crack-related defects caused by environmental factors such as temperature and humidity fluctuations and adverse weather conditions, while ensuring steady development of concrete strength and improving the overall crack resistance of the floor slab[4]. During the hydration and hardening stages, concrete is highly sensitive to moisture and temperature conditions. Delayed or improper curing can easily result in inconsistent deformation between the surface and interior of the concrete, leading to irreversible cracking. Therefore, differentiated curing plans should be developed according to specific site and environmental conditions.

For routine curing control, the curing start time and duration should be strictly controlled. After initial setting and finishing of the concrete floor slab, curing should be initiated within 12 h by covering the slab with geotextile, moisture-retaining blankets, or other insulating and moisture-preserving materials. Under special conditions such as high temperature, low humidity, or strong winds, curing should begin within 6 h to prevent rapid evaporation of surface moisture and the resulting plastic shrinkage cracks. Under normal climatic conditions, the concrete floor slab should be cured for no less than 7 d. For special concrete containing admixtures or mineral admixtures, the curing period should be extended to 14 d or longer. Throughout the curing period, the slab surface should remain continuously moist, and alternating wetting and drying conditions should be avoided.

For seasonal construction protection, targeted temperature-control measures should be implemented. During summer construction under high-temperature conditions, shading structures and mist spraying or water spraying on the slab surface can be adopted to reduce surface temperature and minimize the temperature difference between the interior and exterior of the slab, thereby reducing temperature-induced cracking. During winter construction under low-temperature conditions, the slab surface should be adequately covered with insulating materials to prevent low-temperature damage and frost-related cracking. Meanwhile, the construction site should be provided with an effective drainage system to promptly remove accumulated water and prevent prolonged water saturation of the subgrade, which could cause softening and differential settlement[5]. These measures can reduce potential cracking risks from both the curing process and external environmental conditions.

3.5 Targeted repair of existing cracks

Repair cracks that have already formed selectively, according to their width, pattern, and severity. Brush fine surface cracks narrower than 0.2 mm with a cementitious capillary-crystalline material to seal them and improve the surface compactness and watertightness; fill shallow cracks 0.2–0.5 mm wide by low-pressure injection of epoxy grout, which bonds and repairs the crack; for through and structural cracks wider than 0.5 mm, rout and clean the crack substrate, seal it with high-

strength repair mortar, and strengthen it with carbon-fiber sheets to restore the load-bearing capacity and integrity of the slab.

4. Conclusion

Cracking of cast-in-place concrete floor slabs arises from the combined action of material, design, construction, and environmental factors: non-standard construction is the dominant cause, material and design deficiencies the principal latent risks, and environmental factors accelerate crack propagation. Crack control is thus a whole-process undertaking — optimize the structural design, control the raw materials and the mix proportions, standardize the workmanship, and attend to curing and repair. These measures effectively reduce the incidence of harmful cracks and improve the stability and durability of floor slabs, offering a reference for construction quality control of similar projects.

References

- [1] Zheng W. Analysis of Concrete Crack Treatment Technologies in Buildings[J]. Journal of Architectural Research and Development, 2023, 7(4).
- [2] Tu Bin, Su Ge, Hong Cheng, Liu Kai, Zhou Haonan. Static Performance Analysis of Special-Shaped Lightweight SI Floor Slab[J]. Journal of Physics: Conference Series, 2022, 2185(1).
- [3] Jinglian Zhen. Causes of concrete cracks in the construction of roads and bridges facing intelligent manufacturing technology[J]. International Journal of Global Energy Issues, 2024, 46(3-4).
- [4] X. C. Hu, H. Hu, M. L. Zhuang, T. C. Wang, H. H. Jiang, X. Z. Ding. Study on the Causes of Asymmetric Cracking of Plateau Concrete Bridge Piers[J]. Strength of Materials, 2024, 56(5).
- [5] Lei Zheng, Maogui Jing, Guoxin Zhang, Lei Zhang. Research on anti-cracking measures for concrete face slabs of rockfill dams under coupled thermal stress and settlement deformation[J]. Results in Engineering, 2025, 28.