# Application Analysis of Integrated Construction of Flowable Solidified Soil and Flooring

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**Abstract.** Flowable solidified soil has good flowability, strong self-compacting performance, and high construction adaptability. When applied to floor backfilling and base construction, it can eliminate many procedures such as layered backfilling, mechanical compaction, and repeated leveling. According to the requirements of integrated flooring construction, the implementation points are discussed from the aspects of mix proportion parameters, flow characteristics, layered pouring, elevation control, and surface reinforcement, while its application effects are evaluated in terms of strength development, bearing capacity, process connection, and forming quality. Reasonable adjustment of the solidifying agent dosage, pouring thickness, and curing conditions can improve the integrity of the backfill layer and the stability of the base layer, providing reference for similar projects.

**Keywords:** flowable solidified soil; flooring construction; integrated construction; layered pouring; bearing capacity.

## 1 Introduction

Indoor flooring backfill is constrained by walls, columns, equipment foundations, and embedded pipelines, which restrict mechanical spreading and compaction. Compared with treating flowable fill, controlled low-strength material, or cement-solidified soil as a uniform replacement backfill, the engineering contribution here is layer-specific solidifying-agent dosage: the lower layers undertake filling and load transfer, while a strengthened top layer becomes the flooring working base under unified elevation control. Thus, the novelty lies in integrating material grading, layered strength allocation, and flooring-process connection, rather than proposing a new binder. Examining parameter determination, layered pouring, top-layer treatment, and bearing verification provides a clear, reproducible construction method for similar confined indoor floors.

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## 2 Preparation and Parameter Determination for Integrated Construction of Flowable Solidified Soil and Flooring

The case material consisted of rotary-drilling slurry, water used for density correction, and a proprietary mineral solidifying agent whose components were $Al_2O_3$, $SiO_2$, and CaO[1]. Stones, agglomerates, and organic debris were screened out before mixing. Because slurry moisture and density varied among batches, water or screened soil was added to reach the target prepared density instead of imposing a fixed water-to-solid ratio. Workability was evaluated after trial mixing. DB31/T 1483—2024 specifies a slump range of 150–220 mm or slump-flow range of 500–700 mm for self-compacting regenerated fill; the final control value should be selected within the class according to pumping distance and filling geometry.

The Shanghai vehicle-depot station-building case required approximately 1,800 m³ of indoor backfill at an average depth of 1.4 m. The rotary-drilling slurry had 49.3% initial moisture content, 1.78 g/cm³ initial density, and a high fines content; its prepared density was corrected to 1,350 kg/m³ before the solidifying agent was introduced. Laboratory strength and flow tests established dosage by functional layer rather than one uniform mixture. The first and second layers were each 0.50 m thick and used 90 kg/m³ of solidifying agent for filling and load transfer. The 0.40 m top layer used 210 kg/m³ to provide the verified working-base strength. These figures denote kilograms of proprietary solidifier per cubic meter of density-adjusted slurry, not the oxide proportions within the product. Before pouring, wall and column boundaries, equipment foundations, embedded pipelines, drainage outlets, pumping routes, and the zoned sequence were confirmed against the design elevations. The main engineering parameters are shown in Table 1.

**Table 1.** Main Engineering Parameters for Integrated Flooring Construction

| Item | Parameter |
|---|---|
| Total backfilling volume | Approx. 1,800 m³ |
| Average backfilling depth | Approx. 1.4 m |
| Initial moisture content of engineering slurry | 49.3% |
| Initial density of engineering slurry | 1.78 g/cm³ |
| Target prepared density | 1,350 kg/m³ |
| Layer thickness | 0.50 m + 0.50 m + 0.40 m |
| Solidifying agent dosage of the lower two layers | 90 kg/m³ |
| Solidifying agent dosage of the upper third layer | 210 kg/m³ |
| Average 28 d compressive strength of the upper layer | 1.22 MPa |
| Characteristic value of foundation bearing capacity | 90–240 kPa |

Note: The parameters in the table are taken from the same indoor flooring backfilling project to ensure data continuity.

# 3 Implementation of Integrated Construction of Flowable Solidified Soil and Flooring

## 3.1 Raw Material Preparation and Flow Performance Control

The raw material proportion should meet the requirements of pumpability, self-leveling, and stable solidification. Before the engineering slurry enters the mixing equipment, its moisture content and density should be tested, and the amounts of water and solidifying agent should be adjusted according to the target density instead of directly applying a fixed mix proportion. During mixing, the slurry should first be made uniform, after which the solidifying agent should be added gradually until the color and consistency of the slurry become uniform.

Low flowability raises pumping resistance and leaves unfilled zones around walls, columns, and pipelines; excessive flowability promotes segregation and bleeding, increases shrinkage, and may ultimately reduce final strength[2]. Trial batches were therefore checked for pumpability, overall filling completeness, segregation, and bleeding before the value was fixed. During production, the cylinder flow test was repeated by batch, with moisture content and prepared density rechecked when spread changed. Continuous mixing and delivery limited flow loss with time, while batch adjustment prevented uncontrolled water addition from improving spread at the expense of stability and hardened performance.

## 3.2 Layered Pouring and Flooring Elevation Control

Pouring construction should proceed continuously by zones and layers. Before construction, elevation control lines should be marked on walls or structural columns, and temporary control points should be arranged in advance according to the designed top elevation. After the flowable solidified soil is conveyed to the working surface through pumping pipelines or chutes, pouring should proceed from lower areas toward higher areas, with the discharge outlet kept close to the filling surface so as to reduce the risk of segregation caused by excessive height difference.

The total filling thickness of the project was approximately 1.40 m, of which the first and second layers were both 0.50 m thick and the third layer was 0.40 m thick. The upper layer should be poured after the lower layer has initially stabilized, thereby reducing interference between layers. Areas around walls, equipment foundations, and densely arranged pipelines mainly rely on the self-flowing property of the material for filling, while manual flow guidance may be used as an auxiliary measure when local filling is insufficient. During construction of the top layer, elevation should be carefully rechecked, and a straightedge or laser level should be used to inspect surface flatness so that the top surface can directly serve as the construction reference for the subsequent flooring base. The layered arrangement is shown in Figure 1.

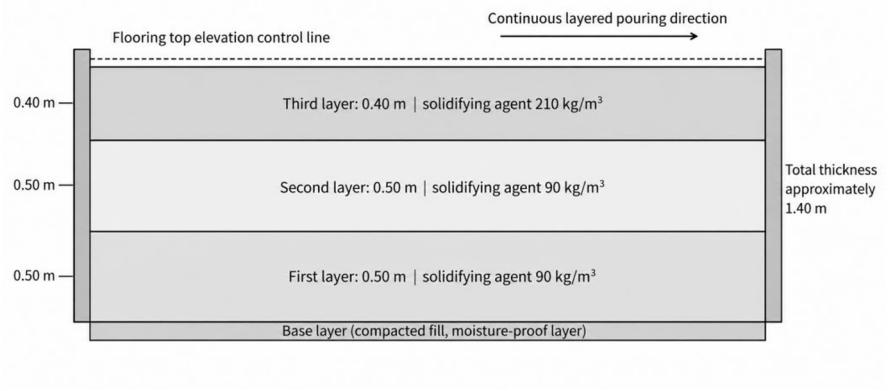



**Fig. 1.** Schematic Diagram of Layered Pouring and Elevation Control of Flowable Solidified Soil

### 3.3 Elevation Transfer and Dynamic Three-Dimensional Coordinate Correction Technology

The key to integrated flooring construction is that the performance of the top layer cannot be controlled according to the requirements for an ordinary backfill layer. The lower two layers mainly serve the functions of filling, load transfer, and settlement limitation, whereas the top layer should also accommodate base bearing requirements, personnel passage, and loads from subsequent construction procedures[3].

In the case project, the solidifying agent dosage of the third layer was increased to 210 kg/m³, enabling the 0.40 m-thick top layer to form a working layer with relatively high strength. After pouring, covering and curing should be carried out promptly to prevent rapid surface moisture loss and consequent shrinkage cracking. Before the material reaches the required strength, concentrated stacking and passage of heavy equipment should be prohibited.

After curing, the surface integrity, elevation deviation, and local loose areas should be inspected, and minor defects should be repaired in time. Once the flooring meets the requirements for subsequent construction, operations such as the moisture-proof layer, leveling layer, or finishing layer can be directly connected. In this way, the conventional repeated spreading and compaction of backfilling and base construction can be transformed into continuous forming and one-time elevation control, thereby highlighting the process advantages of integrated construction.

## 4 Effect Analysis of Integrated Construction of Flowable Solidified Soil and Flooring

### 4.1 Strength Development and Bearing Performance

After integrated construction is completed, strength and bearing capacity are important indicators for determining whether the top layer can serve as a flooring base. The

unconfined compressive strength of flowable solidified soil specimens can be calculated from the ratio of the compressive failure load to the loaded area:

$$f_c = \frac{F}{A} \tag{1}$$

where $f_c$ is the unconfined compressive strength, MPa; $F$ is the failure load of the specimen, N; and $A$ is the loaded area of the specimen, mm².

In the case project, the average 28 d core compressive strength of the upper third layer reached 1.22 MPa, and the values at all measuring points were higher than 0.8 MPa. The characteristic value of the foundation bearing capacity measured on site was 90–240 kPa. These results indicate that increasing the solidifying agent dosage of the top layer and ensuring continuous curing can transform flowable solidified soil from a simple filling material into a component of the flooring base with stable bearing capacity.

In practical applications, excessively high strength should not be pursued blindly. The design value should be determined according to the flooring use, equipment load, and subsequent construction load, and on-site sampling and bearing capacity test results should be used as the basis for acceptance.

### 4.2 Construction Efficiency and Process Connection

Traditional indoor flooring backfilling usually requires spreading, layered compaction or tamping, supplementary filling, leveling, and secondary leveling of the base. In confined areas, construction is also easily restricted by the operating radius of compaction machinery. After being placed through pumping or chutes, flowable solidified soil can naturally fill areas around walls, column bases, and pipelines by virtue of its own flowability, while large-area leveling can also be achieved during the forming process, reducing the frequent entry and exit of machinery[4].

For an indoor backfilling project with a volume of approximately 1,800 m³, orderly connection of material mixing, conveying, layered pouring, and top-surface elevation control can significantly shorten waiting time and process transition time. The improvement in efficiency mainly results from “less compaction, less transfer, and less supplementary filling,” rather than merely increasing the pouring rate.

Construction organization should take into account the production capacity of the mixing station, pumping distance, zoning dimensions, and initial setting time to ensure continuous pouring in each zone. Once the top layer reaches the condition required for personnel access, the subsequent flooring procedure should be carried out promptly, thereby further reducing the interval between backfilling and base construction.

### 4.3 Forming Quality and Flooring Service Foundation

The key requirements for the forming quality of flowable solidified soil include dense filling, a flat surface, stable interfaces between layers, and controllable long-term

settlement. Since large compaction machinery is not required, the risk of voids caused by insufficient compaction around pipelines and structural corners can be reduced. Through unified elevation control and top-surface screeding, the continuity of the base surface can be improved.

During construction, attention should still be paid to fluctuations in moisture content, local bleeding, interruption of pouring, and inadequate curing. If surface laitance, cracks, or local looseness occurs, treatment should be completed before subsequent flooring operations. For areas subjected to relatively large loads, core strength and bearing tests should be combined to determine whether the design service requirements are satisfied.

The flooring base formed in this manner has the advantages of an intact construction surface, relatively uniform strength distribution, and convenient connection with subsequent procedures. The coordinated application of flowable solidified soil and flooring construction essentially makes use of its flowability, self-compacting performance, and adjustable strength to reduce repeated procedures between conventional backfilling and base construction, thereby improving overall construction organization efficiency while ensuring bearing capacity and forming quality[5].

## 5 Conclusion

The integrated organization of flowable solidified soil and flooring construction can make full use of the material's advantages of self-leveling, self-compaction, and adjustable strength, while reducing repeated spreading, compaction, and leveling procedures in conventional backfilling. During construction, the solidifying agent dosage and flow performance should be reasonably determined according to the designed bearing requirements, layered pouring should be adopted to control filling thickness and flooring elevation, and the performance and curing management of the top layer should be strengthened. Through comprehensive control of strength, bearing capacity, forming quality, and process connection, the overall stability of the backfill layer and flooring base can be improved, enabling construction quality and operational efficiency to remain coordinated and providing reference for the application of similar flooring projects.

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