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Article Title: Fundamental Mechanisms of Concrete Bleeding in Bored Piles

Fundamental Mechanisms of Concrete Bleeding in Bored Piles

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ABSTRACT

Concrete bleeding in bored pile scan cause substantial defects such as channelling or air pockets in pile shaft of diaphragm walls. The repair of such damage can be costly and time consuming. The mechanism of concrete bleeding in bored piles and diaphragm walls is well known among construction professionals, but there a sons how concrete bleeding occurs remain insufficiently understood to date. This paper introduces a potential model to explain the fundamental mechanism of concrete bleeding or channelling in deep foundations (e.g. concrete bored piles or diaphragm walls). The model is based on a well-established theory from the disciplines of soil mechanics and geotechnical engineering. The transfer of knowledge from the discipline of geotechnical engineering to another (concrete technology) assumes that fresh concrete is a three-phase system consisting of aggregate (gravel and sand), fluid (cement paste and excess design water) and air. The application of external pressure on to fresh concrete inside a deep foundation due to self-weight of the fresh concrete column causes the redistribution of pore-water pressure, resulting in a reduction of void space inside the aggregate matrix. This change in aggregate density is likely to cause concrete bleeding if potential drainage paths exist inside the fresh concrete matrix. Such drainage paths will provide 'escape routes' to release the excess pore-water pressure (water or cement paste) to the surface of the pile by forming bleeding channels or voids inside the hardened concrete. The existence of potential drainage paths, the lack of fines in the fresh concrete matrix in combination within sufficient aggregate grading and the addition of too much design water (above the optimal water content for a given aggregate combination) have been identified as key factors contributing to concrete bleeding and channelling in deep foundations (e.g. bored piles and diaphragm walls).

Keywords: concrete bleeding, deep foundations, bored piles, concrete defects, bleeding channels

1 Background

Concrete bleeding in bored piles and diaphragm-wall panels has resulted in considerable defects in deep-foundation elements. Other than defects caused by issues related to concrete work ability (e.g. 'matressing' where the fresh concrete cannot flow entirely through the reinforcement cage, 1, 2), stability-related defects are typically caused by concrete bleeding or channelling. Figure 1 shows bleeding of a bored pile shortly after completion of concrete placement via the tremie method and typical voids/channels in the hardened concrete matrix caused by bleeding of fresh concrete.

Based on the author's professional experience and the assessment of a large number of defective concrete bored piles, diaphragm wall panels and other deep-foundation elements,

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concrete bleeding typically begins within one hour after completion of the concrete placement. The bleed water or cement paste starts 'bubbling up' from below, either in a central location of the pile shaft (usually the location of the extraction point of the tremie pipe), along the reinforcement bars, or along the temporary or permanent steel casings. Depending on the effective slump retention time of the fresh concrete, bleed water and/ or cement paste could flow to the surface of the pile for a duration which can vary between a few minutes' up to several hours.

It is important to highlight that concrete bleeding as specified in AS1012.6 'Bleeding of concrete' (3), is generally not relevant for bored piles, diaphragm walls or other deep-foundation elements. The fresh concrete in such applications is exposed to externally applied pressure (1, 2) caused by the self-weight of the fresh concrete. The vertical pressure applied by the self-weigh tofthefreshconcreteinsidea20mdeepbored pile is typically around 25 kPa/m depth. Resulting to about 500 kPa at the pile base at 20 m depth. This significant pressure effects the performance of the fresh concrete during setting and hardening.

The methods of assessing concrete bleeding in AS1012.6 (3) are noted equate to assess concrete bleeding under pressure inside a deep foundation element. Alternative test methods for such an assessment include the filtration test method (1, 2), which is a robust and practical testing method to directly evaluate the potential risk and susceptibility to fresh concrete instability arising from concrete bleeding under pressure or the segregation of the fresh concrete in deep foundations.



Figure1: *Concrete bleeding in a bored pile, approximately 20minafter placement (left); bleeding channels and void sin the hardened concrete as a result of concrete bleeding (right).*

2 Consequences of Concrete Bleeding in Bored Piles

Bleeding of fresh concrete in deep foundation elements can result in mild to severe structural defects in pile sand diaphragm wall panels (1, 2, 4, and 5). As water or cement paste are pushed out of the fresh concrete matrix, the fluids tend to flow towards the surface. During this process, fines and cement paste can be washed out, leaving behind voids, channels or clusters of voids inside the hardened concrete matrix (Figures1and2). Depending on their size and location, such

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channels, voids and cavities can potentially reduce the structural and durability performance of the reinforced concrete elements.



Figure 2: *Bleed water typically travels upwards close to the centre of the pile (left) or along reinforcement bars(centre), causingvoids, channels and debonding of reinforcement bars(right).*

Concrete-core drilling on defect concrete piles and diaphragm wall elements has revealed that such void scan vary in size and complexity, having been found to be single voids or a network of voids forming channels and clusters (Figures 1 and 2). The final assessment is sometimes difficult to obtain because the full range and severity of defects cannot be entirely assessed by using core drilling, as the core sections always represent a very small and limited cross-sectional area of the effected element.

In the author's experience, defects resulting from concrete bleeding in bored piles or diaphragm walls are typically found in the top half of the shafts or panels. Some publications claim that only the top 1-m is affected by concrete bleeding (6) but other more recent research shows that voids and channels were observed at much deeper depth (5). Based on the author's experience, the great majority of hardened concrete defectsindeep-foundation elements are foundin the top1-10 m below the cut-off level.

3 Triggering of Concrete Bleeding in Bored Piles

Concrete bleeding in deep foundation elements is typically triggered by the external pressure applied by the self-weight of the fresh concrete. As a result of the applied external pressure, the void space of the selected aggregates is reduced and due to there duction of the volume of the solid particles, cement paste and water which was confined inside the void space of the aggregates is pushe dout of the fresh concrete matrix.

For optimal performance, it is critical for the fresh concrete to achieve adequate work ability and stability(7). Acceptable concrete work ability ensures sufficient flow of the fresh concrete and the ability to fill voids and pass through obstacles and obstructions (e.g.dense reinforcement cages).

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The workability of fresh concrete for deep foundations is usually achieved through ensuing sufficient quantities of water, (high range) water reducers (e.g. super plasticizers) and the selection of suitable aggregates (shape and grading). The achievement of adequate stability requires ensuring there is suitable aggregate grading, sufficient fines content and the optimal amount of water to fill the voids of the fresh concrete matrix. Chemical admixtures can enhance the stability performance of fresh concrete, but segregation of the fresh concrete might occur when chemical admixtures are over-dosed(13).

The balance between work ability and stability is critically important for the design of any concrete mix for deep foundations as water is required to ensure sufficient workability. However, at the same time the addition of toomuch design water to the fresh concrete could compromise the stability of the fresh concrete and concrete bleeding under pressure might be triggered.

3.1 Fines content

Through the performance analysis of a large number of tremie-concrete mixes over the past decade, the author has observed that concrete mixes with balanced aggregate grading curves, including a minimum fines content of particles<600microns, generally performed satisfactorily with no visual signs of bleeding.

As highlighted by Eisenhut et al. (8), the amount of fines in tremie-concrete mixes is critically important for achieving the required packing density (stability) and the optimal surface area (workability) for concrete for deep foundations. Fines will typically ‘lubricate’ the fresh concrete, improving the work ability, passing ability and flow. The packing density of the aggregates, an important factor in achieving the stability of the fresh and hardened concrete, depends on the grading as well as on the shape and form of the specific aggregates. The Fuller curve optimises the grading for rounded aggregates to achieve the maximum achievable packing density of approximately 90% (9). However, the packing density decreases with an increasing packing index (8). Therefore, the optimal (maximum) density can be achieved only through a redistribution of the aggregate grading and the inclusion of much finer fractions (to fill the smaller voids). Thus, the fines content seems to be very important for optimising the packing density and the surface area of the (tremie) fresh concrete, and consequently for the ability to retain water and to resist bleeding under pressure.

Based on the author’s experience with poorly and adequately performing concrete mixes that have been used for the construction of deep foundations (e.g. bored piles or diaphragm walls) in Australia and New Zealand over the past decade, the fines content of <600 microns should not be less than 25% of the combined grading curve. However, this value can be as high as 35-40% and must be verified by further research and testing. It should be used only as an indication to initially assess the general suitability of a selected aggregate combination to be used for concrete for deep foundations.

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3.2 Optimal water content

As described above, fines in concrete mixes can be useful to fill small voids in the aggregate matrix and to optimise the packing density. Based on the assessment of the packing density for a particular aggregate grading curve (or concrete mix design), the void content of the proposed aggregate can be determined.

Figure3 presents the result so fade tailed assessment of three different tremie concrete mixes with varying water content and its influence on the fresh concrete's stability (assessed by the filtration press). Each of the three test mixes was batched in the laboratory with water contents ranging from 160 l/m3 to 190 l/m3.Filtration tests on fresh concrete samples were carried out for the initial water contents of 160 l/m3andsubsequently for each increment of design water levels in steps of 5 l/m3. The results are presented inFigure3, and it appears that each mix had its 'optimal' water content for the given aggregate configuration.

It appears that full saturation of the selected aggregate was achieved at a different level for each of the three test mixes, and when water was added above the optimal water content, it was almost completely pushed/squeezed out during the filtration test.

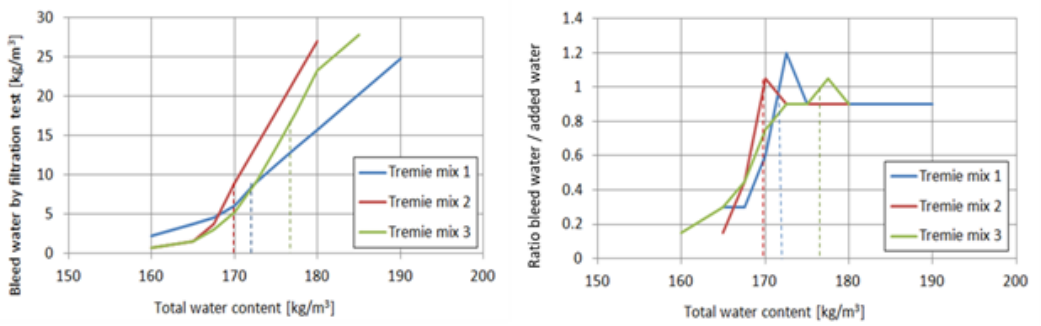


Figure3: *Optimal water content for three trial mixes determined by the filtration test (2)*

Figure 3 (right) displays the ratio between measured bleed water per increment above 160 l/m3and the added water per increment (5l/m3) reaching a saturation level for each mix, ranging from about0.9to1.0.

The comparison indicates that at a ratio close to 1:0, full saturation of the available void space with cement paste (or design water) was reached and all excess fluid was pushed out of the aggregate matrix as a result of the externally applied pressure, simulating the self-weight of the fresh concrete. It is important to highlight that the tests were conducted using 5 bar pressure over 5-minute intervals for each filtration test (1), simulating the external pressure applied by 20 m of self-weight of the fresh concrete. It can be expected that the optimal water content will vary depending on the pressure applied externally during the tests.

The optimal water content for the three mixes was assessed to be:

- 170l/m3 (TremieMix1),

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- 172l/m3 (TremieMix2) and,
- 178l/m3 (TremieMix3)

In theory and based on the test results displayed in Figure 3, Tremie Mix 3 can accommodate the highest amount of fluid (cement paste and water) when applying 5 bar external pressure over a period of 5 minutes. This information is important for selecting the maximum amount of design water for each mix design. If, for example, the work ability requirements for Tremie mix 1 would necessitate 185 l/m3 of water, the likely hood of bleeding under pressure would be high. As presented in Figure 3, Tremie Mix 1 can accommodate only170 l/m3 of fluid (cement paste or water) and the excess 15 l/m3 would be pushed out of the fresh concrete matrix when external pressure is applied, resulting in possible defects in the hardened concrete matrix through the creation of bleeding channels. In addition, the workability of the fresh concrete would be reduced, and the risk of defects caused by a lack of workability might increase unless sufficient concrete admixtures are applied to enhance concrete workability. It is important to assess the performance of the fresh concrete by understanding the limitations of the void space and packing density of the selected aggregates under external pressure.

4 Fundamental Mechanism of Concrete Bleeding in Bored Piles

Concrete is a three-phase system, consisting of solids (coarse and fine aggregates, sand as well as cementitious materials), fluids (cement paste and/ or (excess) design water) and gases (air). If the voids between the coarse and fine aggregates are completely filled with cement paste (and air), the system is fully saturated. In most concrete applications, fresh concrete is not subject to external pressure as for deep foundations, underwater placement or concrete pumping. However, external loading or pressure can significantly affect the behaviour of the fresh concrete matrix by reducing the available void space.

4.1 Terzaghi's modified the oryofone-dimensional consolidation

In soil mechanics, the behaviour of one-dimensionally loaded, partially or fully saturated granular soils under confined boundary conditions is known as 'Terzaghi's one-dimensional consolidation' theory (10). This theory assumes that one-dimensional, external loading is applied vertically onto a fully saturated soils ample, and that horizontal confinement is given. Figure 4 presents the principles of Terzaghi's one-dimensional consolidation theory (10). It is important to high light that in this (soil mechanical) context, consolidation is considered the 're-establishment of equilibrium of stresses' (10) rather than the definition of consolidation in concrete science as the 'process of reducing the volume of voids, air pockets, and entrapped air in a fresh cementitious mixture, usually accomplished by inputting mechanical energy'(11). Terzaghi's one-dimensional consolidation theory can be slightly modified and used to describe the stress redistribution inside the fresh concrete matrix of a bored pile or diaphragm wall panel. There is one significant difference between Terzaghi's theory and the modified application to model the behaviour of fresh concrete in deep foundations: cement hydration. This is where

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Terzaghi's model needs to be slightly a mended as the bleeding phenomenon is not only a physical process of expelling excess water in the fresh concrete mix but also a chemical process where cementitious material is hydrating.

However, the basic model seems to be suitable for explaining the fundamental mechanism of concrete bleeding under pressure in bored piles or in other deep-foundation elements as shown in Figure4. If bored piles are installed with steel liners (temporary or permanent) or in impermeable ground conditions, the pore-water-pressure release typically occurs through drainage paths along the longitudinal pile axis towards the surface (e.g. along reinforcement cages, casings or the tremie-pipe channel) and the drainage path could be assumed to be comparable as shown inFigure4.

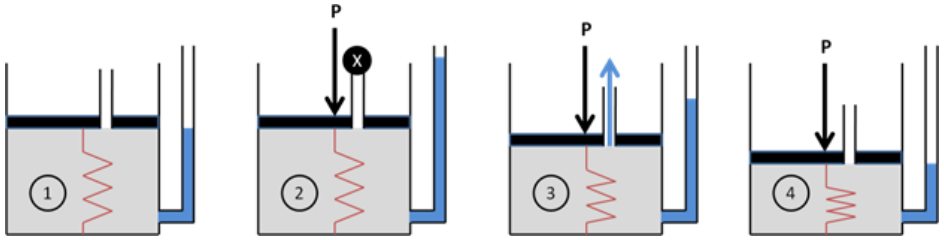


Figure4: *Terzaghi's one-dimensional consolidation theory (10).*

During the initial state, the fully saturated granular soil (or fresh self-consolidating concrete) is completely saturated (all voids are filled with fluid or cement paste) and the sample is confined inside a circular mould or steel casing; no lateral movement is possible, no external loads are applied and the system is in balance.

The total stress (σv) is defined as the sum of effective stress (σ'v) and pore-water pressure (u). In Terzaghi's theory, the soil is modelled as a spring, and represents the effective stress component of the model, which is carried by soil matrix or 'skeleton'. Drainage is possible during the initial stage (the drainage path is open) and the pore-water pressure is not elevated. The drainage path is then closed, and the externally applied load 'P' will be carried completely by the pore water, which takes up all change in total stresses. The effective stress (soil matrix or soil 'skeleton') remains unchanged as the volume of the sample remains constant, there is no change in the void space/content.

When a drainage path is unlocked and made available, the excess pore-water pressure can be released by pushing some fluid out of the system (e.g. bleed water or cement paste). This decreases the pore-water pressure inside the sample and increases the effective stress because the soil 'skeleton' (the spring in Terzaghi's model) begins to take on the additional external load as the pore-water pressure is decreasing. Because of the increased effective stresses, the spring compresses or the volume of the soil reduces, as the soil particles are redistributed while excess water continues to escape through the drainage path (bleeding under pressure).

The increased effective stresses (compression of the spring) carried by the soil 'skeleton' result in a reduction in voids, leading to densification of the aggregates and are duct ion in void space.

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Once the excess pore water (or cement paste) has completely drained out of the reduced void space, the pore-water pressure also dissipates, and the flow stops. The system is in balance again, and the additional load is completely carried by the soil (spring).

It is important to understand that this consolidation process of a granular soil or aggregate is time dependant because it is a process of pressure dissipation. The existence of a flow path is critically important, as is the permeability of the existing soil (or fresh concrete) inside the impermeable mould (or steel casing). Hence, it is important to consider the permeability of the soil which forms the bore whole wall.

If no drainage path is available during the application of the external load 'P' over an extended period of time 'T' ('T'> retardation time of the fresh concrete), no bleeding under pressure will occur, and the excess pore-water pressure will be converted into effective stresses as the cement will begin to hydrate and set. The newly formed cement gel utilises the available pore water for the hydration process. While the cement sets, there will be a redistribution of the external load from pore-water pressure to effective stresses inside the hardened concrete matrix and equilibrium will be established without visible drainage (bleeding).

In this amended model, the phenomenon of bleeding under pressure is not only a physical process of expelling excess water in the concrete but also a chemical process where Cementitious material is hydrating.

4.2 Drainage paths

Terzaghi's modified one-dimensional consolidation theory can be used to describe the stress redistribution inside the fresh concrete matrix of a bored pile or diaphragm wall panel. Bleeding under pressure can be observed when drainage occur sand the cement paste is pushed out of the fresh concrete matrix by external loading.

In Terzaghi's theory, the excess water escapes through an open drainage path at the surface of the saturated soil sample. Analysing concrete defects in deep foundation elements created by bleeding channels very often indicate that water or cement paste moved along the pile reinforcement (Figure 2) or inside steel liners towards the surface. Therefore, it should be considered that pile reinforcement and steel liner scan act as a drainage path for excess bleed water or cement paste when external pressure is applied.

Excess bleed water can also escape sideways through the soil formation if drainage through the borehole wall is possible. The upper parts of bored piles are often stabilised by temporary or permanent steel casings, but in granular soil formations (e.g. sand or gravels), drainage into the soil formation below temporary casings can occur instantaneously, and concrete bleeding would occur without being noticed at the surface.

It should also be considered that artesian groundwater can penetrate into the fresh concrete if the external water pressure is higher than the internal concrete pressure. Assuming that pile reinforcement is typicallylocatedonly50mmor75mmfromthesoil–concrete interface, external water could enter the fresh concrete matrix and be pushed up the reinforcement bars towards

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the surface, washing out the concrete inside the cover zone and creating a drainage path for the artesian ground water layer along there in for cement cage.

Bleeding channels are sometimes found close to the centre of the vertical pile axis. The 'plug theory' (3, 13) assumes that the first batch of concrete is always located at the top of the fresh concrete column. During the tremiepour, the first batch is pushed up wards, and this plug is typically the most mature concrete of the entire pour. Therefore, slump retention and retardation times should be applied to the first batch of concrete.

Based on this assumption, another potential flow path for excess bleed water could be created by removing the tremie pipe by forming a channel of softer (less mature and more workable) concrete through the plug and connecting the deeper layers with the surface. There moval of the pipe is likely to create 'piston effect', forming a potential drainage path for excess water to flow the surface.

4.3 Sand boiling during earthquakes and the link to concrete bleeding in bored piles

Soil liquefaction is particularly common in clean, loses and, or in gravelly and saturated with water. Such fully saturated sands that are subject to liquefaction are usually located close to the surface. When earth quake induces forces 'shake' the sand, the pressure applied by the seismic waves deforms and compresses the sand, increasing the water pressure in the pore spaces between the sand grains, there by turning the sand–water mixture into a liquid. This temporary over-pressuring (cyclic shear stress or cyclic loading) is repeated as long as strong shaking occurs. Sometimes, liquefiable sand is overlain by a more cohesive and impermeable material (e.g. clay or pavements), which serves to confine the compressed water in the sand. Cracks in the impermeable surface layer can create a drainage path for the liquefied sand, which is pushed to the surface, appearing as a sand volcano (12) or known as sand boiling.

The mechanism of sand boiling, which indicates soil liquefaction during and after earthquakes, allows liquefied soil to flow to the surface through flow paths (cracks) in non-liquefiable soil layers close to the surface. This phenomenon of' sand boiling' seem to follow a comparable mechanism like concrete bleeding under pressure in bored piles, where the removal of the tremie pipe creates a potential flow path through the more mature (and less permeable and workable) concrete close to the top of the pile.

Figure5presentstheverticalcross-section of a sand volcano or sand boil, showing the liquefied sand layer, non-liquefiable clay cap, and the sand dike (drainage path through cracks in the clay layer) transmitting the liquefied sand to the surface. In the right image of Figure 5, the mouth of a bleeding channel in the centre of a bored pile has an appearance which is comparable to that of a sand volcano (centre left). The mechanism of release of excess pore-water pressure inside the fresh concrete matrix (prior to setting) inside a bored pile is comparable to sand boiling after soil clique faction during or after aseismic event.

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Figure 5: *Sand boiling (left) and concrete bleeding in bored piles (right) seem to follow a similar mechanism, by which a saturated, unconsolidated granular material is mobilised to move up wards through a 'capping layer' by excess pore- water pressure*

5 Conclusions

Concrete bleeding in deep-foundation elements such as bored piles or diaphragm wall panels can cause voids, cavities and/or channels inside the hardened concrete matrix after setting and hardening of the tremie concrete. Concrete bleeding in deep foundations is typically triggered by external pressure, caused by the self-weight of the fresh concrete. Therefore, AS1016.6 'Bleeding of concrete' (3) is not suitable for assessing concrete bleeding under pressure, observed in bored piles or diaphragm walls. The filtration test should be used as an alternative to measure the stability of the fresh concrete for deep foundations (1, 2).

To date, the fundamental mechanisms of concrete bleeding in deep-foundation elements such as bored piles or diaphragm walls has not been investigate din detail. This paper applied the well-established principle of Terzaghi's one-dimensional consolidation theory from the field of soil mechanics in a slightly modified form to the field of concrete technology.

The fresh concrete inside a deep foundation is typically exposed to (sometimes significant) external loading by self-weight and hydrostatic pressure. Fresh tremie concrete requires excellent flow characteristics and therefore the fresh concrete is typically fully saturated with cement paste to achieve optimal work ability and self-compacting behaviour. When external pressure is applied on the fresh concrete matrix, the additional load is initially carried by the pore-water pressure because the concrete is usually volume stable, which means the concrete is confined and cannot move laterally or vertically (downwards). If drainage paths are available and volume changes are possible, the pore-water pressure is converted into effective stresses as the void space is reduced and the density of the aggregate is increased. The additional external load is entirely carried by the aggregates and over time by the hydrated cement after setting and hardening. This is where Terzaghi's model needs to be modified as the bleeding phenomenon is not only a physical process of expelling excess water in the fresh concrete but also a chemical process (cement hydration).

When drainage paths are available, the excess pore-water pressure forces surplus cement paste(or excess water) out of the fresh concrete matrix until the stress equilibrium is re-established and the additional load is carried by the aggregate skeleton (effective stresses).

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Given that this process typically increases the density of the aggregate and reduces the void space, the workability of the fresh concrete will change because of the escape of cement paste, making the concrete less workable.

Based on the observation of numerous bleeding defects on bored piles and diaphragm walls, it is likely that reinforcement bars can act as drainage paths and that the raising water can reduce/ damage the bond between the steel and the fresh concrete, which can result in substantial structural defects.

Permeable granular soil layers at the pile/ soil interface can also act as potential drainage paths and bleeding can occur below ground level, unnoticed at the surface. Another potential drainage path can be created by extracting the tremie pipe from the fresh concrete. A channel of fresh concrete inside more mature concrete at the surface of the fresh concrete plug is left behind after removing the tremie pipe. However, this scenario seems more likely when plug flow is assumed (2, 13), where the first batch of concrete remains at the top of the concrete column throughout the entire concrete pour.

This pattern of creating a flow path through less permeable material has also been observed during sand boiling, during or after earthquakes. Liquefied and is pushed from deep erlayers (below the ground surface) by excess pore-water pressure through drainage paths to the surface. It can be assumed that a similar mechanism could be applicable for concrete bleeding in deep-foundation elements.

To mitigate concrete bleeding in deep-foundation elements, it is important to assess the void space of the proposed aggregate combination before and after applying the estimated amount of external loading to be applied by hydrostatic pressure or self-weight of the fresh concrete. The reduction in void space will significantly affect and limit the amount of water that can be added to the fresh concrete to fill the available voids after densification. If too much water is added initially (before exposure to the external loading), the excess water will be pushed out under pressure, and concrete bleeding is likely to occur if drainage paths are available and the pore-water pressure is sufficient to push the excess cement paste or water up wards.

Chemical admixtures are able to assist to improve fresh concrete stability (13) but a robust mixed sign with adequate aggregate grading, optimal water content and sufficient fines content is the foundation for a well-performing concrete mix design.

Observations have indicated that a minimum of 25% of fine spas sing the combined grading curve at 600 microns, along with the optimal water content (depending on the selected binder type and content), seem to have a positive effect on mitigating concrete bleeding under pressure in bored piles and diaphragm walls. Laboratory trials are necessary to confirm sufficient fine contents.

Further research is required to investigate the influence of reduced void space in aggregates. Laboratory tests should be established to assess the densification effects of aggregates under pressure. This is important for determining the optimal water content for efficient concrete-mix designs for deep foundations.

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The application of related engineering disciplines likes oil-mechanics and geo technical earthquake engineering in combination with the observation of defective concrete piles, were used to introduce a model to describe the fundamental mechanism of concrete bleeding under pressure in deep foundation elements.

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References

1. Year: 2012, Recommended Practice: “Tremie Concrete for Deep Foundations”.

2. Joint EFFC/DFI Concrete Task Group, Year: 2018. “Guide to Tremie Concrete for Deep Foundations”, European. Federation of Foundation Contractors and Deep Foundation Institute.

3. Standards Australia, AS1012“Methodsoftestingconcrete”, Standards Australia.

4. Beckhaus.K; Larisch.M.D, Year: 2011, “New performance criteria for fresh tremie concrete”, Workshop Performance-based Specifications for Concrete, pp. 311–318.

5. Koq.Y.C, Year: 2009, “Integrity problem of large diameter bored piles”, Journal of Geo technical and Geo environmental Engineering, Vol: 135, no: 2, pp. 237–245.