**SUMMARY:**
This document forms the elaboration in concept of the survey amongst members of the EFFC Technical Working Group regarding the experiences on tremie concrete in deep foundations and suggestion for the EFFC-DFI Research and Development on this subject.
Input has been received from 18 members representing 11 countries.
Any comment or addition regarding the conclusions are welcome, especially since this is the concept version. Due to the time-schedule comments received before February 28th are highly appreciated.

## Main conclusions:

### 1. Part 1 – Materials

1.1. **For cement the types CEM II or CEM III are preferred. Probably based on low heat development and sulphate resistance.**

1.2. **If possible d the use of CEM I should be avoided but also CEM V and even CEM II are mentioned!**

1.3. **Fly ash is known for its binding capacity. For the relative effectiveness which leads to strength and durability in comparison with cement a k-value (0– 1) has to be used. For workability the k-value approach can be ignored. Questionable is whether the required minimum cement amount in the EN206 is meant for strength or for workability. In some countries fly ash is used as 1:1 replacement for cement till a certain amount and in some countries the k-value approach seems to be used for any replacement.**

1.4. **More clarity regarding the background for the minimum requirement of cement in deep foundations is necessary. Using the term "binder" instead of "cement" should be considered, in case the requirement is related to workability.**

1.5. **The requirement on gravel diameter seems clear and right, although an additional discussion about the understanding and possible consequences might be useful. Most critical is the relation to the horizontal clear space at lapping rebar of the vertical reinforcement. *0 mm for gravel $D_{max}$=20mm. So 4:1 for $D_{max}$=20mm, but 5:1 for $D_{max}$=16mm. But without overlapping 100mm for $D_{max}$=32mm= 3:1.
So is it quite clear and what is the influence multiple reinforcement layers or of the cover thickness?**

1.6. **For the requirement on the amount of fines an Increase of the minimum amount should be considered.**

1.7. **Regarding the use of additives like plasticisers and retarders quite varying anwers have been given. Even from the same country. So attention in the Guideline would be usefull and if possible also (as desk study) in the R&D.**

1.8. **Extra requirements or restrictions on the use of silica fume, the sand/gravel ratio, the maximum strength class and the amount of bleeding should be considered.**

### 2. Part 2 – Testing of concrete

2.1. **In most countries suitability tests quite normal, although some contradictional answers are given. The tests are executed together with the supplier. Suitability tests are especially needed in case of a less experienced supplier, use of new type of constituants or extraordinary requirements have to be met.**

2.2. **The nescessity of acceptance control tests seems to be a standard understanding. Slump or slumpflow tests are normally done, although not on every delivery. Question could be if more tests are necessary and, if yes, daily or per delivered load. Questions are raised if**

**measurement of flowability and thixotropy (by slumpflow tests?) would be more helpful or additional tests on stability / bleeding. If easy and fast it could be part of the acceptance test, otherwise part of the suitability test.**
**However, this might also be dependent of the challenging condition of a project.**

2.3. **Testing on stability against bleeding is mentioned as important. Several testing methods are used. Interesting to investigate the value of these.**
**Testing of the cover-zone is mentioned only by a few members. But this might change in the future.**

## 3. Defects in piles and diaphragm-walls.

3.1. **Segregation, bleeding and lack of flowability are considered to be the main cause for defects.**
3.2. **Regarding the production of concrete differences of actual concrete characteristics from the requested values is a major concern.**

## 4. R&D program EFFC-DFI.

4.1. **For the desk- and/or laboratory-study research of the influence of aggregate distribution and the fines content is recommended.**
4.2. **Extra topics for R&D:**
- 4.2.1. **Decisive factors for the quality in the cover zone,**
- 4.2.2. **defining requirement values for the various test-methods,**
- 4.2.3. **sensitivity of additives regarding dosage and temperature,**
- 4.2.4. **explanation of reliability of laboratory tests,**
- 4.2.5. **Behaviour of mixtures in dense reinforcement and identification of the flow by using coloured concrete might be considered for field testing in the R&D**

| | | | |
|---|---|---|---|
| | ***Part 1: Materials*** | | |
| | **Is the type of cement normally specified by you, the Deep Foundation Contractor (DFC)? If so, which type?** | | |
| NL | CEM III/B | FR(dm) | Yes, depends on the aggressiveness of the soil. |
| ES | No | FR(bp) | We generally choose ourself the type of cement |
| DE | Yes, CEM III/A | BE | CEM III , preferably CEMIII/C |
| AT (i) | Yes, we typically use local CEM II …. | CZ | It is not given by us. |
| AT (k) | No | CZ(2) | It is not – normally it is given by proposal of concrete producer. We consider CEM II / B-S to be ideal. |
| AT (z) | No; it's normally specified by the client | PT | Usually the type of cement is specified in the contract documents, general contractor or by the ready-mix concrete suppliers. |
| HU | It is rare that they prescribe the cement type, they rather prescribe the environmental exposure class of concrete to be used. | UK(1) | Yes, OPC |
| IT | We generally don't specify the cement. In case we do, CEM type II or type IV. | UK(2) | No |
| FR(dw) | Either by the client (contract) or by us according to the standards. | UK(3) | No |

**Conclusions: In case the contractor can decide CEM II or CEM III are preferred. Probably based on low heat development and sulphate resistance.**

| | | | |
|---|---|---|---|
| | **Are there types of cement you don't like or refuse to work with? If so, which?** | | |
| NL | CEM I | FR(dm) | N/A |
| ES | According to the standards. | FR(bp) | For concrete in piles, most of time it is not a question because this choice is up to us. |
| DE | Yes, CEM I. | BE | Yes, CEMI and CEMII. |
| AT (i) | No | CZ | Sulphate-resisting cement – quick setting and hardening, concrete mixing plants do not produce it. |
| AT (k) | No, if the cement used in the concrete confirms "Richtlinie Bohrpfähle" | CZ(2) | We do not like to work with quick cements CEM I 42,5 R. They have steep increase and it is difficult to assure workability. |
| AT (z) | N/A | PT | We are not aware. |
| HU | None. | UK(1) | ? |
| IT | CEM I, CEM V. | UK(2) | No |
| FR(dw) | No. We adapt the concrete mix design to the raw materials available (cost and delivery considerations) according to the standards. | UK(3) | No |

**Conclusions: If possible some contractors avoid the use of CEM I and also CEM II and even CEM II and CEM V are mentioned.**

| | Do you use fly ash as cement replacement? If so, is there a limit in amount and is the replacement calculate with k=1 or lower? | | |
|---|---|---|---|
| NL | Maximum amount 30%.) K=0.4 (CEM I) or K=0.2 (CEM III) | FR(dm) | Made by experience, we use at least 190kg/m3 and some additional ashes. |
| ES | Yes. Limits for EN 197-1 CEM II. K≤0.40 (≤0.65 if specifically tested); according to Spanish EHE-08. | FR(bp) | We do not like cement replacement. If done, we are scarcely informed (according to EN 206, furnishers consider it is a normal practice and that they don't have to inform us) |
| DE | Yes, max. 70 $kg/m^3$, 70 kg fly ash for 20 kg Cement. | BE | Sometimes, k is lower. |
| AT (i) | Yes, we use flyash. There is a limit in Germany, but we are allowed to use more (100 $kg/m^3$) | CZ | Yes. |
| AT (k) | Yes, we use flyash. Max. 25 % (CEM I), k=0,4 e.g. CEM I 42,5 | CZ(2) | Yes, we use it as filler. The calculation is given by ČSN EN 206 (max. k = 0,4) |
| AT (z) | N/A | PT | Typically concrete suppliers use fly ash as a cement replacement and may range from 20% to 35% of the amount of the binder. |
| HU | In Hungary the experiences are not good with fly ash (poor quality of available fly ash), so we generally do not use it. | UK(1) | Yes PFA and GGBS. |
| IT | Yes, we do use Fly Ash.<br>K is defined according to the standards and type of fly ash. | UK(2) | No PFA available in UK anymore so no longer an option. |
| FR(dw) | Yes, but very rarely. No amount limitation and k=1 can be use. | UK(3) | Yes fly ash used. |

**Conclusions: No clear conclusion possible. Probably highly influenced by national experience and availability.**

| | In the EN1536 and EN1538 a minimum cement amount is given. Is this requirement clear and right? | | |
|---|---|---|---|
| NL | Not clear that the amount is needed only for workability. De term "binder" would be more suitable with k-value=1. Combined with additives less cement / binder can be used even for C38/45. | FR(dm) | We do not follow that. |
| ES | Yes (I guess it refers to EN-206 Annex D, since those requirements are not in the 1536/1538 anymore. Same for other questions). | FR(bp) | It should be clear and we should not have to wonder if there is cement replacement…<br>It is right according to concrete resistance; it is not sufficient according to other properties we expect from concrete (pumping, rheology,…)<br>DON'T limit the question to EN 1536/1538; EN 12699 is also a concern! |
| DE | Yes. | BE | Clear and right. |
| AT (i) | Yes. | CZ | The requirement is clear. We found the resulting strength of concrete mixes too high for geotechnical applications. |
| AT (k) | No, the range is too wide, therefore we have the Austrian "Richtlinie Bohrpfähle" | CZ(2) | The requirement is clear. Amounts of cement are redundant (e.g. 400 kg CEM for DW – EN 1538) |
| AT (z) | Clear: Yes. Right: No; should be a minimum binding material. | PT | Actually, EN206 Annex D. It's clear. |
| HU | clear, and in our opinion, it is right, too. | UK(1) | ? |
| IT | Yes | UK(2) | Yes |
| FR(dw) | Yes but it could be suitable to talk about "binder" and not "cement". It's more adapted to the foundation works and allows to use additives suitable for the workability and the durability. | UK(3) | No. 380Kg/m3 for CFA piles bored under submerged conditions is high. |

**Conclusions: The term 'binder' instead of "cement" looks more appropriate. Although no unanimity. Statement Belgium not according daily practice and check AT-standard!**

| | In the EN1536 and EN1538 a maximum gravel diameter is defined. Is this requirement clear and right? | | |
|---|---|---|---|
| NL | For us a stricter maximum diameter is preferred when the quality of the cover zone is important. | FR(dm) | We do not follow that. |
| ES | Yes, but we are familiar with limits for % than can pass that diameter. | FR(bp) | It is clear but not sufficient in some cases. |
| DE | Yes | BE | Clear and right. |
| AT (i) | Yes | CZ | The requirement is clear. We use very often smaller grain size (16 mm) for Kelly and CFA piles. |
| AT (k) | No, the range is to wide, therefore we have the Austrian “Richtlinie Bohrpfähle”. | CZ(2) | In Czech Republic the Dmax – 22 mm (normally Dmax 16 mm) is used. In the standart the Dmax 32 mm it stated. |
| AT (z) | Yes | PT | Actually, EN206 Annex D. It’s clear. |
| HU | Depending on the technology (pumped concrete or tremie concrete), we define our internal maximum aggregate diameter anyway. | UK(1) | ? |
| IT | Yes. | UK(2) | Yes |
| FR(dw) | Yes. It’s a requirement for the strength, but this doesn’t deal with the stability. | UK(3) | N/A |

**Conclusion: The requirement on gravel diameter seems clear and right, although an additional discussion about the understanding and possible consequences might be useful. (check AT-standard)**

| | In the EN1536 and EN1538 a minimum amount of fines is given. Is this requirement clear and right? | | |
|---|---|---|---|
| NL | Yes | FR(dm) | We do not follow that. |
| ES | Yes, but a note might clarify that it is not allowed to reduce the amount of cement by increasing the fines content. | FR(bp) | It is clear but not sufficient in some cases. |
| DE | Yes | BE | Clear = ok<br>Requirement should be higher ( min 450 kg/m3) |
| AT (i) | Yes | CZ | Yes. |
| AT (k) | No, mostly we need more amount of fines, therefore we have the Austrian “Richtlinie Bohrpfähle”. | CZ(2) | Yes. |
| AT (z) | N/A | PT | Actually, EN206 Annex D. It’s clear. |
| HU | It is all right, but for pumped concrete for example CFA we use an additional value to check: cement + sand (0/4mm fraction) together should be over 1200kg/m3. | UK(1) | ? |
| IT | Yes. | UK(2) | Yes |
| FR(dw) | Yes but the stability has to be verified with a bleeding test. | UK(3) | N/A |

**Conclusion: Increase of the minimum amount of fines should be considered. (check AT-standard)**

| | **Do you think restricions in type and/or amount of additives like plasticisers and retarders are necessary? If so, why and how?** | | |
|---|---|---|---|
| NL | In case stability and durability is critical in combination with other materials or at specific concentrations. | FR(dm) | We do not use such additives. |
| ES | Yes, it must be clear that the use of additives must not be used to reduce the cement or fines content, because it can affect critically the workability during the necessary time to place the concrete. | FR(bp) | It wouldn 't be necessary if furnishers were aware of our utilisation. (Some propose concrete which are fitted to our purpose; in that case, our knowledge or restrictions of the composition is only useful but not necessary) |
| DE | A maximum of 4 hours for the execution is necessary. | BE | Restrictions on superplasticisers because of short term action. |
| AT (i) | No there are no restrictons nessecary. If everyone knows how to work with these materials. | CZ | Sometime it could be advantage. |
| AT (k) | Yes, because we are no chemical engineers. E.g. we want no plasticisers on PCE-basis. | CZ(2) | We do not think that restrictions of additives are necessary. |
| AT (z) | N/A | PT | Admixtures are needed to reduce w/c ratio and to improve the workability and stability. |
| HU | Not, but test mixings are preferred if the ingredients are different from recipes already tried and used. | UK(1) | Yes you can overdose plasticisers and retarders and need to ensure there is control by prior testing if limits exceeded. |
| IT | No. | UK(2) | No |
| FR(dw) | No. It's not suitable to have restrictions on admixtures depending to the location and the products available on the concrete plant. | UK(3) | Yes. Greater control of additives required. |

**Conclusions: No unanimity. Due to difference in understanding the question or different experiences and knowledge?**

| | **Do you miss other requirements or restrictions in the composition of concrete in deep foundations?** | | |
|---|---|---|---|
| NL | N/A | FR(dm) | N/A |
| E | N/A | FR(bp) | Yes; see FNTP research. |
| D | No | BE | Minimum sand/gravel ratio higher; Clear specs for bleeding and stability. Clear limits for total aggregate gradation. |
| AU (i) | No | CZ | Designers require to high concrete classes.<br>Problems with Plasticisers. |
| AU (k) | No | CZ(2) | No. |
| AU (z) | N/A | PT | N/A |
| H | Crushed aggregates should not be used. | GB(1) | ? |
| I | No | GB(2) | No |
| F (dw) | No. Maybe a limit with the silica fume amount could be helpful. | GB(3) | Limits need to be applied to allowable bleed. |

**Conclusions: Extra requirements on silica fume, sand/gravel ratio, maximum strength class and amount of bleeding should be considered.**

| | | | |
|---|---|---|---|
| | **What kind of behaviour or compositions needs extra attention in the guideline and so also in the research?** | | |
| NL | The behaviour of additives in concrete mixtures for tremie concrete. | FR(dm) | N/A |
| ES | Setting time. | FR(bp) | N/A |
| DE | N/A | BE | Duration of workability (flowability); stability of mix against segregation and bleeding; influence of minimum sand/gravel ratio on flowability. |
| AT (i) | Shrinkage | CZ | N/A |
| AT (k) | The composition of the concrete (especially the additives and the cement) should be done in the right way so that the special foundation concrete doesn't bleed. | CZ(2) | Questions on cement type, content of water, Dmax. |
| AT (z) | N/A | PT | N/A |
| HU | N/A | UK(1) | ? |
| IT | Workability vs time, viscosity vs time, bleeding vs time. | UK(2) | Workability retention, bleed. |
| FR(dw) | Behaviour: bleeding and viscosity (filtration test under pressure, ASTM C232, inverted cone). Composition: maybe to have warnings when high strength, low W/C ratio or high silica fume content are needed. | UK(3) | Consistence of supply. There is too much variation in supply of an agreed mix design. |

**Conclusions: No strict conclusions, but a number of suggestions. To be considered.**

| | | | |
|---|---|---|---|
| | ***Part 2: <u>Testing</u>***<br>**Are suitability tests normally done prior to the execution of a project? If so, together with the supplier?** | | |
| NL | No, not as standard practice or by requirements. | FR(dm) | Most of the time on big projects. Otherwise we use typical formula which has been already checked. |
| ES | Only in specific projects. In those cases, tests are carried out together with the supplier. | FR(bp) | Depending on the owner and the supposed specific difficulties (on our hand) |
| DE | No. | BE | Yes; preferably with supplier. |
| AT (i) | Yes, we probably have to do them with the supplier. | CZ | Not, exceptionally. |
| AT (k) | No | CZ(2) | Yes we test together with concrete producer workability in time. |
| AT (z) | Yes; from the supplier. | PT | When the concrete is provided by the concrete suppliers, preliminary tests are not done. |
| HU | Yes and yes. | GB(1) | Yes with all suppliers. |
| IT | Yes for both. | GB(2) | Yes and yes. |
| FR(dw) | Each tremie concrete is tested in the concrete plant with the supplier. We test slump, flow, filtration, bleeding, viscosity, strength and this behaviour over time. | GB(3) | Until recently they were generally only carried out on larger projects, sometimes with the supplier, sometimes not. |

**Conclusions: Suitability tests are not standard in every country yet. For the countries where suitability tests are used, the program of testing should be compared.**

| | If suitability tests are not usual, why not? | | |
|---|---|---|---|
| NL | For normal specs like slump-tests it is up to the supplier. | FR(dm) | N/A |
| ES | For the concrete supplier, production costs prevail over the quality requirements. | FR(bp) | No time. |
| DE | We normaly use compositions from the concrete companies. | BE | N/A |
| AT (i) | N/A | CZ | Tests are not requested by clients. Certification from concrete mixing plants is enough. |
| AT (k) | Because normally the supplier has a conformation certificate | CZ(2) | N/A |
| AT (z) | N/A | PT | N/A |
| HU | N/A | UK(1) | ? |
| IT | N/A | UK(2) | Lack of knowledge within DFC industry. |
| FR(dw) | N/A | UK(3) | Time. Cost. Logistics. |

**Conclusions: When suitability tests are not performed it is mostly based on trust in the supplier or lack of knowledge which parameters have to be tested and what requirement values shall be applied.**

| | Are there special conditions in which you would concern suitability tests? | | |
|---|---|---|---|
| NL | When not standards tests or specifications need to be controlled. | FR(dm) | N/A |
| ES | Heavy reinforced elements, mono-piles, long times of concrete placement (large/deep DW panels), etc. | FR(bp) | Evolution of rheology and/or geological characteristics are the main concerns. |
| DE | Yes, for special executions. | BE | All conditions. |
| AT (i) | N/A | CZ | No |
| AT (k) | No, if the concrete confirms the “Richtlinie Bohrpfähle”. | CZ(2) | In case of big volume panels – long workability, dense reinforcement – good consistence |
| AT (z) | N/A | PT | We are concerned with the concrete bleeding. |
| HU | Especially if there is a new provider / location we have not worked with, so provider is not familiar with our technological needs. | UK(1) | ? |
| IT | N/A | UK(2) | I would always recommend testing. |
| FR(dw) | More specifically, suitability tests are essential for high strength or low W/C ratio concrete, or in case of sensitivity tests. | UK(3) | All rotary bored piling and diaphragm wall projects. |

**Conclusions: No uniform conclusion possible**

| | Are control tests normally done on site during execution? If so, what kind of tests and with what frequency? | | |
|---|---|---|---|
| NL | Yes, slump-flow for each delivery on site. | FR(dm) | We are doing compressive stress, minimum of 3 per jobsite and regulations following ASIRI standards. |
| ES | Slump test. | FR(bp) | Systematically, compressibility tests.<br>Frequently Abrams cone. |
| DE | Yes, slump test and the stability of test cubes. Frequency is based on the national standard | BE | Yes; slump tests (min 2à 3 times per pour)<br>Slump in time of a mix (duration) 1 per pour;<br>Mix stability, bleeding (min 1 per pour) |
| AT (i) | Yes, we have to control during every execution. | CZ | Yes. Concrete Consistency and temperature are tested each day. |
| AT (k) | Normally not. | CZ(2) | Yes. Each day consistence test from first three automixes. Workability test befor jobsite commencement |
| AT (z) | Yes; identity test | PT | Control tests are done at the concrete receiving. Usually we do slump test. |
| HU | Daily sampling for compressive strength tests, daily random check for consistency (usually flow table test) | UK(1) | Temperature (winter), Slump, Cube, Flow, Pot bleed test (spot checks). |
| IT | Yes, always.<br>Slump / Flow, each truck mixer. | UK(2) | Flow/slump test of every load, cube tests as per spec. |
| FR(dw) | Yes, tests are done during the production (slump, flow, bleeding, UCS) especially on the first delivery trucks. The supplier is called in case of disagreement about the concrete quality or acceptancy. | UK(3) | Flow/slump and retention. Cube testing. VSI. Bauer bleed and bleed pot on bored piles and D Wall. |

**Conclusions: Slump or slumpflow tests seem to be normal, although not on every delivery. The answers from Austria show contradictions. Question could be if more tests are necessary and, if yes, daily or per delivered load.**

| | If control tests are not usual, why not? | | |
|---|---|---|---|
| NL | Not mandatory in the standards. | FR(dm) | Control test made on every jobsites. |
| ES | N/A | FR(bp) | N/A |
| DE | N/A | BE | N/A |
| AT (i) | N/A | CZ | N/A |
| AT (k) | Because conformation test are available, but if the client wants to test it is his responibility. | CZ(2) | N/A |
| AT (z) | N/A | PT | N/A |
| HU | N/A | UK(1) | ? |
| IT | N/A | UK(2) | N/A |
| FR(dw) | N/A | UK(3) | Time. Cost. |

**Conclusions: N/A**

| | Are there special conditions in which you would concern control tests? | | |
|---|---|---|---|
| NL | N/A | FR(dm) | N/A |
| ES | Heavy reinforced elements, mono-piles, long times of concrete placement (large/deep DW panels), etc. | FR(bp) | N/A |
| DE | N/A | BE | All conditions. |
| AT (i) | N/A | CZ | Yes. Concrete behaviour in case of higher temperatures. |
| AT (k) | Normally not. | CZ(2) | Yes,workability test in case of long casting. |
| AT (z) | The same conditions as they are in the ground (temperature, pressure, …) | PT | Usually not. |
| HU | N/A | UK(1) | ? |
| IT | N/A | UK(2) | Control tests are mandatory. |
| FR(dw) | More specifically, suitability tests are essential for high strength or low W/C ratio concrete, or in case of sensitivity tests. In those case the frequency should be rise. | UK(3) | All rotary bored piling and diaphragm wall projects. CFA projects also but less frequently. |

**No uniform conclusions possible**

| | What kind of characteristics would you like to be tested? | | |
|---|---|---|---|
| NL | At least slump-flow but when possible also thixotropy and stability. | FR(dm) | N/A |
| ES | Slump evolution over time. | FR(bp) | Evolution of rheology in time. |
| DE | Nothing | BE | Slump variation in time, starting slump, stability and bleeding. |
| AT (i) | Rheological items, water retarding items. | CZ | Workability = speed of setting and curing. |
| AT (k) | Concrete bleeding tests. | CZ(2) | Consistence, bleeding.<br>Generally- what is the concrete behaviour under enormous load of hydrostatic pressure? |
| AT (z) | Bleeding, demixing, stability. | PT | VSI, flow test and filter press test. |
| HU | N/A | UK(1) | ? |
| IT | Workability vs time, bleeding vs time, viscosity vs time. | UK(2) | Flow/slump, workability retention. |
| FR(dw) | Bleeding (filtration under pressure and natural bleeding) and viscosity (inverted cone). Stiffening over time could be interesting too. | UK(3) | Flow, flow retention, bleed, segregation. |

**Conclusions: Standard flowability and thixotropy (by slumpflow tests?). Additional stability / bleeding.**

| | Do you use specific test methods not commonly known? If so, why and how? | | |
|---|---|---|---|
| NL | Slumpflow for delivery control. In the suitability tests also Austrian filterpress and J-ring. D-wall quality checked by corings with focus on the cover-zone. Inclusions along the joints checked with CSL- measurements. | FR(dm) | No, we follow the norm NF. |
| ES | N/A | FR(bp) | N/A |
| DE | N/A | BE | Bauer press test (for stability and bleeding) |
| AT (i) | N/A | CZ | N/A |
| AT (k) | Austrian concrete bleeding test described in the "Richtlinie Weiche Betone" | CZ(2) | Filtration apparatus Fann-press to investigate bleeding. |
| AT (z) | N/A | PT | N/A |
| HU | Water resistance test, on hardened concrete specimens – important for d-walls (Hungarian extra environmental exposure class) | GB(1) | Baur filter bleed test. |
| IT | N/A | GB(2) | No |
| FR(dw) | The tests mentioned previously were selected after a series of site tests. They are relevant, easily used on site and discriminant. | GB(3) | N/A |

**Conclusions: Bleeding control is important. Several testing methods are mentioned. Interesting to investigate the value of these. Testing after completions are hardly mentioned!**

| | Do you miss specific testing procedures in the EN-standards? If so, which? | | |
|---|---|---|---|
| NL | Other methods than slump or slump-spread are not mentioned | FR(dm) | N/A |
| ES | N/A | FR(bp) | N/A |
| DE | Nothing | BE | Bleeding tests, mix stability test. |
| AT (i) | In-situ rheological tests. | CZ | |
| AT (k) | Yes, concrete bleeding tests. | CZ(2) | None |
| AT (z) | N/A | PT | N/A |
| HU | N/A | UK(1) | ? |
| IT | No | UK(2) | N/A |
| FR(dw) | Those mentioned in question 7. | UK(3) | N/A |

**Conclusions: Most members seem quite comfortable with only slump measurements**

| | *Part 3: Defects in piles and D-walls*<br>**Which kind of defects do you experience related to the composition or behaviour of concrete?** | | |
|---|---|---|---|
| NL | Porosity in the cover, bleeding channels along the vertical rebar. | FR(dm) | N/A |
| ES | Segregation, mattressing, channelling and slurry inclusions. | FR(bp) | Defects of short time resistance (cut-off is too easy) |
| DE | None | BE | Rapid slump loss resulting in bad reinforcement cover and "mattress "forming.<br>Bleeding weakening concrete cover. |
| AT (i) | Holes, maybe cracks. | CZ | Pulling up reinforcement cages due quick concrete setting. |
| AT (k) | Problems to built in the reinforcement, holes regarding to bleeding. | CZ(2) | Bleeding – non-homogeneous concrete, loss of workability – interrupted casting, reinforcement not propperly covered outside (mattressing) |
| AT (z) | Wrong consistence. | PT | Lack of workability and bleeding. |
| HU | N/A | UK(1) | Exposed steel behind bars, reduced cover due to flow. |
| IT | Bleeding channel, segregation, honeycomb. | UK(2) | Too stiff / too wet. |
| FR(dw) | Channeling, mattressing or cold joints. | UK(3) | Segregation, bleed, flow. |

**Conclusions: segregation, bleeding and lack of flowability form the main cause for defects.**

| | **Which kind of defects do you experience related to the placement or behaviour of concrete?** | | |
|---|---|---|---|
| NL | N/A | FR(dm) | N/A |
| ES | Segregation, low slump, limited flowability, etc. | FR(bp) | Problems related to insertion of reinforcement in fresh concrete. |
| DE | None | BE | Blocked tremie pipes due to badly mixed concrete and lumps. |
| AT (i) | Great defects, as holes or sedimentation of gravel. | CZ | Pulling up reinforcement cages due quick concrete setting. |
| AT (k) | Problems with unmixing of the concrete. | CZ(2) | E.g interrupted casting. |
| AT (z) | Inclusions; the flow around the reinforcement was not enough | PT | Lack of workability and bleeding. |
| HU | Dense reinforcement makes placement often complicated and is a possible source for honeycombs. | UK(1) | Soft head where concrete mixes with Bentonite. |
| IT | Sand pockets, defects on joints. | UK(2) | Does not flow around rebar. |
| FR(dw) | Mattressing, cold joints, sand pocket and contaminated joints. | UK(3) | N/A |

**Conclusions: Loss of flowability is a main concern**

| | Which kind of defects do you experience related to the production of concrete? | | |
|---|---|---|---|
| NL | N/A | FR(dm) | N/A |
| ES | Lack of cement content, wrong dosage of additives (on site), etc. | FR(bp) | Irregularity of production (concrete in the morning is not the same than which in the afternoon…) |
| DE | None | BE | Variations in slump at arrival, concrete lumps (bad mixing) resulting in bad quality of the placed concrete and gravel “nests”;<br>Wrong concrete mixture according to concrete ticket. |
| AT (i) | Sedimentation. | CZ | Wrong concrete consistency. |
| AT (k) | Sedimentation, stiffness, bleeding. | CZ(2) | Unsuitable consistence – low or high. |
| AT (z) | Frozen components in concrete. | PT | Non uniform cement characteristics in some countries, with different results in strength and workability. |
| HU | Clay lumps or other pollution in aggregates (e.g. drift wood) | UK(1) | Slump / flow, concrete understrength, poor mixing on occasion with “lumps” or segregated with high aggregate content. |
| IT | Segregation. Slump compliance. | UK(2) | Non- compliant with spec. |
| FR(dw) | Bleeding, mattressing (dosage variations, moisture balance, production rate) | UK(3) | Flow problems. |

**Conclusions: Differences in actual concrete characteristics from the requested values cause a lot of problems**

| | Which kind of defects do you experience related to the transport of concrete? | | |
|---|---|---|---|
| NL | N/A | FR(dm) | N/A |
| ES | Setting starts, loss of water, unauthorized water addition, etc. | FR(bp) | (not very frequent) freezing. |
| DE | None | BE | Segregation due to insufficient drum rotation.<br>Problems of slump due to being stuck in traffic. |
| AT (i) | Stiffness | CZ | Wrong concrete consistency. |
| AT (k) | Stiffness, too much additional water. | CZ(2) | Lowered consistence – under S4 (long transports in summer) |
| AT (z) | N/A | PT | Initial set up time. |
| HU | N/A | UK(1) | Slum flow due to time in lorry. |
| IT | Slump compliance, viscosity, setting. | UK(2) | None |
| FR(dw) | With some admixtures, we need a minimum transport time to improve their effects. Sometimes the delivery rate is too low. | UK(3) | Flow problems. |

**Conclusions: all above suggestions are helpful**

| | ***Part 4: R&D program***<br>**Are there comments or suggestions for desk study in the R&D program?** | | |
|---|---|---|---|
| NL | N/A | FR(dm) | We work on several project with Lafarge. We do have also some works with a PhD student. |
| ES | N/A | FR(bp) | N/A |
| DE | No | BE | Determine clear boundaries for the aggregate sieve curve (gradation) for maximum density concrete and auto compacting concrete<br>Maximum slump up to and including S5 as long as concrete is stable.<br>Increase of time between mixing and placement because of increased duration of workability.<br>Increase of time between placement of two mixers because of increased duration of workability. |
| AT (i) | No | CZ | N/A |
| AT (k) | N/A | CZ(2) | Not available due to absent knowledge of R&D program. |
| AT (z) | N/A | PT | N/A |
| HU | Water resistance testing and quality control; really necessary and realistic concrete cover values. | UK(1) | ? |
| IT | N/A | UK(2) | N/A |
| FR(dw) | The modelisation of concrete placement into the Dwall panels or piles would be essential. | UK(3) | N/A |

**Conclusions: Influence of aggregate distribution and the fines content might need extra attention**

| | **Are there comments or suggestions for laboratory testing in the R&D program?** | | |
|---|---|---|---|
| NL | N/A | FR(dm) | N/A |
| ES | N/A | FR(bp) | N/A |
| DE | N/A | BE | Influence of aggregate gradation and fines content on workability, stability and bleeding of concrete. |
| AT (i) | Not so far. | CZ | N/A |
| AT (k) | N/A | CZ(2) | Not available due to absent knowledge of R&D program. |
| AT (z) | N/A | PT | N/A |
| HU | Fine matrix content (sand+cement) finetuning and setting of requirements; concrete cover values. | UK(1) | ? |
| IT | N/A | UK(2) | N/A |
| FR(dw) | No, it's complete enough. | UK(3) | N/A |

**Conclusions:**

| | **Are there any other comments or suggestions for the R&D program?** | | |
|---|---|---|---|
| NL | Research on the characteristics decisive for the quality of the cover zone. | FR(dm) | N/A |
| ES | To be specific in target values in the final report. | FR(bp) | N/A |
| DE | N/A | BE | Colour coding (or other tagging) of concrete to determine the flow and mixing of the concrete in the trench of subsequent mixers and to follow behaviour of the concrete after shortening the tremie pipes. Influence of W/C ratio in combination with additives on workability, stability and end result of the placed concrete. |
| AT (i) | No | CZ | N/A |
| AT (k) | N/A | CZ(2) | Not available due to absent knowledge of R&D program. |
| AT (z) | N/A | PT | N/A |
| HU | N/A | UK(1) | ? |
| IT | N/A | UK(2) | N/A |
| FR(dw) | In the US, reproducing the site concrete in the Lab is not relevant because it introduces a lot of mistakes (moisture, dryness, mixing energy, …). We have be careful to the conclusions. | UK(3) | Effect of temperature on particular additives used in concretes. Some additives seem very sensitive to minor changes in w/c ratio and/or temperature. Concrete companies do not yet have proper control of this. |

**Conclusions: Extra topics for R&D: Decisive factors for the quality in the cover zone, defining requirement values for the various test-methods, sensitivity of additives regarding dosage and temperature, explanation of reliability of laboratory tests..**

| | **Are there comments or suggestions for field testing in the R&D program?** | | |
|---|---|---|---|
| NL | N/A | FR(dm) | N/A |
| ES | Test concrete behaviour on heavy reinforced elements. | FR(bp) | N/A |
| DE | N/A | BE | Behaviour of workability in time of a mix<br>Colour coding( or other tagging) of concrete to determine the flow of the concrete in the trench of subsequent mixers. |
| AT (i) | Not so far. | CZ | N/A |
| AT (k) | N/A | CZ(2) | Not available due to absent knowledge of R&D program. |
| AT (z) | N/A | PT | N/A |
| HU | N/A | UK(1) | ? |
| IT | N/A | UK(2) | More work needs to be done to define the parameters for testing stipulated by EFFC tremie guide. |
| FR(dw) | No | UK(3) | N/A |

**Conclusions: Behaviour of mixtures in dense reinforcement, identification of the flow by using coloured concrete might be considered for field testing in the R&D**

# Abbreviations
## and what they stand for

- NL – The Netherlands, Volker Staal en Funderingen
- ES – Spain, Aetess
- DE – Germany, Franki Grundbau
- AT (i) – Austria, Implenia, Thomas Pirkner
- AT (k) – Austria, Keller, Thomas Pirkner
- AT (z) – Austria, Züblin, Thomas Pirkner
- HU – Hungary, Chovanyecz Enikő
- IT – Italy, Trevi
- FR (dw) – France, Soffons, Diaphragm-wall
- FR (dm) – France, Soffons, Deep mixing/mixed-in-place
- FR (dp) – France, Soffons, Bored pile
- BE – Belgium, Fondedille / Eiffage
- CZ – Czech Republic, Keller
- CZ (2) – Czech Republic, Zaklada
- PT – Portugal, Texeira Duarte
- UK (1) – Great Britain, David Hard, Bachy-Soletanche
- UK (2) – Great Britain, David Hard, YA(?)
- UK (3) – Great Britain, David Hard, RP(?)