Report over testing of Inexa bathroom units

SBi has participated in a development project sponsored by GI concerning light bathrooms build by smaller prefabricated elements. In the project a general test program for bathrooms build by elements was developed. This test program has been used as basis for the elaboration of a test program for Inexa Bath room units made from factory made elements taking into account the specific construction and the specific materials used for Inexas elements.
The test program for Inexa bathroom units is enclosed as appendix 1.
The testing was performed in the period December 2002 – September 2003 and has been reported in SBi test report, case number 452-109, enclosed as appendix 2. The test report is made as an ordinary test report i.e. giving results but not including an assessment of the product and its expected performance.
During the test period a couple of modifications have been made. These are not mentioned in the text as the main purpose of the work is considered to be the assessment the final product. The modifications are the following:

- A sealant strip has been added in order to achieve a double securement of the watertightness of the joint between the elements.
- Replacement of a sealant strip in order to facilitate the assembling and to improve the securement of the watertightness. The sealant strip is now placed on the inner edge of the elements.
- Change of the design of the floor element due to problems with water penetration. The change implied that the profile on the edge of the floor element in which the wall elements is placed has been lifted in relation to the floor surface. Besides it has been redesigned in order to act as a drain – ”gossip groove” – so any leakiness is reported under the door.

The modifications have been incorporated in the chapter about identification of the product to ensure that reference is made to the tested product.

The present report includes a compilation of test results as well as assessments of the bathroom unit and its elements and materials. In order to facilitate an overview over tests and results the basis for evaluation, results, evaluation criteria and an assessment of the product has been given for each performance property. The basis for evaluation and the evaluation criteria come from appendix 1 whereas test results come from appendix 2.

Please note that basic demands for wet rooms as for example stated in SBi direction 200 must be fulfiled independent of the performed full-scale test. This includes for example requirements to water and sewage installations, ventilation and the action of the floor as a basin able to hold a reasonable amount of water.

Inexa bathroom units comprise a floor element made as a sandwich panel with a 1.25mm galvanised steel plate on each side and a core of strenthening steel profiles and hard mineral wool. As a standard the floor is covered with ceramic tiles. The walls comprise a 0.75mm steel plate on each side of a core of stiff mineral wool (Rockwool, 150 kg/m^3). The wall surface is as a standard covered with ceramic tiles. Construction drawings and photos are enclosed as appendix 3.

Conclusion

The test programme includes tests normally used as part of the documentation necessary to achieve a MK-approval for wet room constructions. In this connection the most important requirement is that the wet room is watertight also after a series of static and dynamic loads – including torsion of the entire unit – and exposure to varying temperature and humidity conditions and water. The tested bathroom unit remained watertight after all tests.
A further investigation of the watertightness of sealant strips and selant compound respectively showed that the joints between the elements remained watertight even if 1of the 2 failed. The unit is furthermore designed with a ”gossip groove” which will reveal if there should be a leak in the walls e.g. in the joints or the pipe penetrations. This ”gossip groove” is an extra security not found in traditional wet rooms.
The used tile adhesives and joint grouts were exposed to accelerated ageing (heat, including heat cycles) and chemicals. In neither test there was any sign of deterioration and consequently tile adhesive and joint grout is assessed to have a long service life without special requirements as to maintenance.

> *On basis of the above it is assessed that a correct made bathroom unit of the tested type will remain watertight for at least 20 years.*

The wet room is typically delivered with finished surfaces clad with ceramic tiles. The tiles are mounted with an epoxy based adhesive with a very good adhesion to the substrate. Change of tiles is done by by first heating each individual tile. When the heat has made the adhesive behind the tile soft it is removed. Mounting of a new tile is done with a special adhesive from the producer of the bath room unit. The use of special adhesive makes it inconvinient to perform repairs and especially it is difficult to change tiles on an entire surface. However, renovation of entire surfaces may be done by conventional methods by setting new tiles on the existing.
Replacement of whole elements is possible but requires specially trained personnel who shall exercise great care – espacially as regards installation of selant strips. The floor element can only be changed by dismantling the entire bathroom unit. It is a prerequisite that installations are not crossing joints.
Change of WC, wash basin, shower etc. is done traditionally.

> *On basis of the above repair /replacement of wall and floor is assessed to be difficult whereas change of WC, wash basin, shower etc. is assessed to be simple and not different from traditional wet rooms.*

The biggest floor elements are so heavy that they can not be transported and installed by 2 persons without use of special equipment. The other elements are lighter and may all be transported by 2 persons. However, the biggest wall elements are so voluminous that they may imply extra loads on the persons when carrying them around tight corners.

> *Based on this it is assessed that the used elements – exept the biggest floor elements – can be installed by 2 persons without need for special equipment.*

Dynamical loads under transport may under certain unfavourable conditions damage the surfaces to an extent where 1 or 2 tiles need to be changed. In such cases special adhesive and joint grout is needed and consequently it should be available in smaller amounts for repair. Other dynamic loads under transport might cause a dent in the flange of a single element. However, these dents have no influence on the performance of the element, including

its watertightness. Installment of the elements is assessed to be simple and robust to minor deviations from the prescribed installment procedure.

Based on this it is not considered to be necessary with rigorous supervision but it will be sensible to emphasize care with transport and installment in order to avoid dents etc.

Finally it should be noted that issues concerning fire is not part of this report. Further information regarding fire may be achieved from Inexa.

Transport

a. Weight and volume declared

Evaluation basis	The weight and volume of the elements must be determined/declared.
Test results	The greatest wall element measures approximately 1.2 x 2.4 x 0.05 m^3 and has a mass of 66.3 kg. The supplied extra floor element measures approximately 1.1 x 1.3 x 0.05 m^3 and has a mass of 120.4 kg.
Evaluation criteria	The weight and volume of the elements must be so limited, that they may be transported and assembled by two persons at most. According to the regulations of the National Labour Inspection (AT circular letter 12/1987) the maximum weight for elements intended for transport and assembling by one person is 50 kg, and for elements intended for transport and assembling by two persons 100 kg. It must be estimated, whether the volume permits carrying up the element in a staircase.
Evaluation	The largest weight and volumes of the elements does not allow the largest floor element to be transported and mounted by 2 persons. This implies that floors shall be assembled of smaller elements or that at least 3 persons are needed for the handling (alternatively special equipment must be used for transport and assembling). The other elements fulfil the requirements for transport and assembling by 2 persons, but can not be handled by 1 person alone. The volume of the largest elements may imply extra load on persons when transporting elements in narrow places.

b. Dynamic load (setting down with a crane when wrapped)

Evaluation basis	A dynamic load is applied to the elements, resembling that they are put down on a concrete support by a crane, i.e. with a speed of 2 m/minute. The load is applied to a corner or a side, depending on which is deemed to be the more unfavourable. By testing, the elements shall be packed/wrapped as this is foreseen to be done in practice, e.g. transported on pallets with corner protections.
Test results	The test was performed with a speed of 4 m/minute instead of the prescribed 2 m/minute. Besides the elements were not wrapped. By putting the elements down against the concrete floor no visible damage was observed. See figure 3 in appendix 3.
Evaluation criteria	The test must not result in damages requiring repair.
Evaluation	The elements are tested in unwrapped condition at a higher speed than demanded. As this highly increased load has not resulted in visible damages the elements are considered sufficiently robust to withstand the dynamic forces to be expected during transport.

c. Dynamic load (steel ball)

Evaluation basis	A dynamic load is applied to fixed floor and wall elements, resembling that they are bumped against a wall. An impact of a 1 kg steel ball with an energy of 20 Nm is applied to an edge or a corner, depending on which is deemed to be the more unfavourable.
Test results	The load was reduced as compared to the originally agreed because a load corresponding to a 1 kg steel ball falling from 2.04 m was considered harsher than the loads/blows to be simulated. By blows against edge and surface of an element with a 1 kg steel ball falling from 1020mm (10 Nm) a dent was formed in the surface and the flange was damaged by blows to the edge (see figure 5 in Appendix 3). There was not observed damages on the tiles. Loads from the steel ball falling from 1530mm (15 Nm) resulted in a dent on the surface and a dent and a damaged tile on the edge (see figure 6 in appendix 3).
Evaluation criteria	The test must not result in damages requiring repair.
Evaluation	The applied blows are assessed to be so harsh that it will only rarely occur during transport and assembling. The dents observed by the testing are assessed to be without significance for the function of the elements including assembling and watertightness. However, a load of a similar size as the largest one applied will require repair and consequently does not fulfil the evaluation criteria.

Assembling

a. Over tightening of joints

Evaluation basis	A test assembly of elements is performed, where assembling operations are done more rough than prescribed, e.g. trying to twist the elements during installation. Besides other unsuitable operations are performed, e.g. wrong installation or dismantling/correction of installed elements.
Test results	No damages or other infavourable observations have been noted during test assembling.
Evaluation criteria	The test must not result in damages requiring repair.
Evaluation	The assembling process is assessed to be easy and robust to minor devations from the intended proces e.g. in the form of twisting etc.

b. Point load

Evaluation basis	The finished floor in a full-scale test room assembled from elements is loaded by a static load of 2250 N through a 25mm steel mandrel.

Test results	No visible damages were observed after 2250 N static load on the floor.
Evaluation criteria	The test must not result in damages requiring repair.
Evaluation	The bath room fulfils the requirement.

c. Sensitiveness to deviation

Evaluation basis	It is assessed whether the performance of the finished room is especially sensitive to deviations in the manufacturing and assembling operations e.g. tolerances on measures due to fabrication and temperature conditions at assembling
Test results	The performance of bathroom unit is not assessed to be especially sensitive to deviations in the assembling process.
Evaluation criteria	If the bath room unit is assessed to be especially sensitive it should be reported.
Evaluation	The bath room unit is not assessed to be especially sensitive to deviations in the assembling process etc.

d. Settlement of corner

Evaluation basis	The bathroom is assembled on a supporting floor. After the assembling is finished the supporting floor is given a "simulated settlement of a joist floor" of 15 mm in one corner (This test is performed before the test for watertightness). If possible the supporting floor is afterwards reset so that the bathroom is brought into position again. Supplementary a floor element is projected over the support and tested with a static load of 2250 N.
Test results	A static load of 2250 N applied on a projected corner – with a projection corresponding to the distance between floor beams in an old floor construction – did not result in any measurable deflection or visible damages.
Evaluation criteria	The twisting of the bathroom must not cause damage, e.g. cracks or leaks.
Evaluation	The bathroom unit is considered to be very resistant to twisting i.e. stable even with a corner projected or in case a support should give way.

e. Need for rigourous inspection

Evaluation basis	It must be evaluated whether there are critical work operations demanding rigorous supervision.
Test results	The assembling procedures are assessed to be simple and without special risks of failures during assembling.
Evaluation criteria	In case it is assessed that there are critical operations during assembling e.g. mounting of joint strips it should be reported.
Evaluation	The assembling is assessed to be simple and without especially critical operations.

Durability and life expectancy

Stability/durability

a. Watertightness - floor	
Evaluation basis	The floor of an assembled, full-scale bathroom is tested according to Nordtest method NT Build 230 (”Bathroom floors: Watertightness”). The test includes changing air humidity, alternating hot and cold water sprayed on the floor as well as static and dynamic loads applied to the floor. If it can be anticipated that the floor in larger bathrooms will be put together by more elements, the test specimen must include an element joint.
Test results	The floor in the tested bathroom was assembled by 2 smaller elements. The floor did not show any signs of water penetration or deterioration after the test.
Evaluation criteria	No damage or weakening of the floor construction must occur during the test. The construction/facing must be designated watertight.
Evaluation	As no damages or water penetration were observed the floor in the bathroom is considered to be suited for use in wet rooms.
Remarks	The above mentioned Nordtest methods are normally considered to give an impression of the watertightness after a prolonged service period exposed to mechanical and hygrothermal loads, as the exposure used in the methods are rather harsh. The Nordtest metods are normally used as the primary test in connection with isssuing MK approvals for bathroom constructions/watertight surfaces.

b. Watertightness - wall	
Evaluation basis	The walls of an assembled full-scale bathroom is tested according to Nordtest method NT Build 058 (”Walls in bathrooms: Watertightness and resistance to water and moisture”) and EOTA Guideline ETAG 003 (”Internal partition kits for use as non-loadbearing walls”). NT Build 058 includes actions of alternating hot and cold water, of high relative humidity in the air, and of mechanical loads on pipes and equipment. ETAG 003 includes action of dynamic load and will be modified for use in an assembled cabin, i.e. reduced height available so that the dynamic load must be applied in an alternative way, tailored to the actual space conditions. The deviation being a shorter rope than prescribed for suspending the bag used for the soft body impact. However, the load is the same.
Test results	By applying the soft body impact to the wall a minor elastic deformation of the walls occurred but no damages were observed neither on tiles or joints. The walls in the tested bathrooms did not show any signs of leakage or deterioration after the test.

A supplementary test of watertightness of joints was performed on joints between wall elements tightened with joint strips alone. At this supplementary test no water penetration was observed.

Evaluation criteria No damage or weakening of the wall construction must occur during the test. The construction/facing must be designated watertight.

Evaluation As no damages or leaks were observed the walls are evaluated to be suited for use in wet rooms. The supplementary investigations were done on the watertightness of joints based on joint strips alone. The test results show that joint strips as well as sealing compound each are capable of ensuring the watertightness alone. On this basis it is assessed that even though the primary joint should fail the joint strip is able to maintain the watertightness. This double security corresponds to the general demands for joints in wet rooms. The wet room has in addition to the double security also a “gossip groove” that reports if a leakage in the wall should occur. This ensures against damages from leaks that are only observed after al long time.

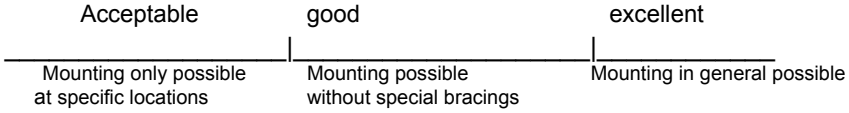
c. Carrying capacity

Evaluation basis The carrying capacity of installation objects and late mounted arm supports and "coathooks", mounted according to the directions of the cabin vendor is tested as follows:

- A lavatory bowl (WC) is loaded by a force of 4000 N, applied on the center of the bowl.
- A wash basin is loaded by a force of 1500 N, applied at a distance of 420 mm from the wall surface or, for smaller wash basins, on the front edge.
- An arm support is loaded with a force of 1000 N, applied where load is expected to act under normal use.
- A "standard coathook" is loaded by a force of 100 N, applied at a distance of 150 mm from the wall surface.
- For a wall hung lavatory bowl and for a washbasin supported by a mounting rack no testing is necessary.

Test results Elastic deformations were observed during the test with WC, wash basin and arm support, but no damages or weaknesses were observed.

Evaluation criteria No damage must occur during the tests. The extent of the mounting possibilities may be judged according to the following band:



Evaluation The the carrying capacity as regards WC, wash basin and arm support are asssessed to fulfil the requirement as no damages were observed.
The extent of mounting possibilities is assessed as “good”, cfr. the band under evaluation criteria.

Remarks	The testing is considered to include assessment of the furnishing possibilities as regards the possibilities for mounting things on the wall, cfr. the point ”Usefulness/flexibility”. In Inexas manual a method for mounting things on the wall is prescribed. This implies that a hole is drilled in the wall and that the hole is filled with silicone sealing compound prior to mounting the screw. The risk for leaks are in this way reduced. Additionally any water penetrating into the wall will eventually be led out by the “gossip groove” reporting a leakage.

d. Adhesion of surface

Evaluation basis	For unknown material combinations, adhesion of tiles/facing is measured by a pull-off test on 100 x 100 mm test specimens cut out of the underlay with corresponding tiling/facing.
Test results	The adhesion of the tiles to the underlay is so good that failure occurred twice between the test machine and the test specimen whereas no failure occurred between the tile and its steel underlay. On this basis it can be concluded that the adhesion is above 0.8 MPa.
Evaluation criteria	An adhesion strength of at least 0.15 MPa shall be achieved.
Evaluation	The adhesion is far above the minimum requirement and is assessed to be “excellent”.

Life expectancy

a. Accelerated ageing

Evaluation basis	Accelerated ageing is applied to individual materials/material combinations if their life expectancy is deemed to be uncertain. The test method must be chosen depending on the material/material combination. First of all, testing is foreseen to be performed on adhesive, sealing compounds and joint grout. Ageing is so far limited to a heat ageing at 60 °C and subsequent assessment of the properties (the properties to be used as indicators are not yet decided but might for example be change in adhesion strength or change in colour).
Test results	Testing of tile adhesive was performed on test specimens consisting of 2 tiles 50x50 mm glued together. The test specimens were heat aged at 60°C for 28 days and were afterwards exposed to a dynamic load with 1000 sinusoidal cycles between 0.0 and 0.3 MPa. The adhesive proved to be so strong that failure in all cases occurred between the test machine and the test specimen for the aged specimens as well as the reference specimens. Failure was in all cases at loads above 3.5

kN and the adhesion/cohesion strength of the adhesive is consquently above 1.4 MPa.

Evaluation criteria Evaluation may be performed based on information about and knowledge on the actual materials, including knowledge on, or evaluation of, physical and chemical compatibility of material combinations, and based on possible results of accelerated ageing tests with single materials or material combinations. In addition, conditions established during the above tests on "Stability/durability" may contribute.

Evaluation The adhesion strength is far above the minimum requirements also after ageing. The probability for good long term performance is assessed to be “excellent”.

b. Attack by chemicals

Evaluation basis The materials with unknown properties or materials assessed to be at risk by chemical attacks are tested by applying the suspected chemicals on the surface and let them act on the surface for 1 hour. The chemicals are chosen from the following list:

1. sodium hypochlorite
2. acetic acid (32 %)
3. iodine in ethanol (1 % solution)
4. Ammonia (24 %)
5. detergent
6. olive oil
7. urine (5 % urea, 0.1 % hippuric acid and 0.01 % carbamide)
8. black shoe polish
9. petrol
10. acetone.

Test results The test results were the following:

1. sodium hypochlorite – no attack
2. acetic acid (32 %) – no attack
3. iodine in ethanol (1 % solution) – no attack
4. Ammonia (24 %) – no attack
5. detergent – no attack
6. olive oil – no attack
7. urine (5 % urea, 0.1 % hippuric acid and 0.01 % carbamide) – no attack
8. black shoe polish – no attack
9. petrol – no attack
10. acetone – no attack.

Evaluation criteria Resistance to chemicals is evaluated subjectively based on a visual examination of the effect of the action.

bad	acceptable	good	excellent
Serious attack	Attack	Easy attack	Not influenced

Evaluation There was no visble effect of the exposure to chemicals of the epoxy based sealant mortar and the resistance against chemicals is consequently assessed to be “excellent”, cfr. the band under “evaluation criteria”.

Remarks

No general test methods exist for assessment of the service life for which reason the testing has been performed on basis of what was considered most relevant. The service life for the materials of the bathroom is evaluated to be at least 20 years - except from possible surface treatment, elastic sealing compound and similar items, which do not participate in the primary sealing against penetration of moisture and water, and which normally demand frequent maintenance.

Fire resistance requirements

Evaluation basis

The fire resistance requirements of the Danish Building Regulations 1995 (BR 95) must be met. Normally the fire resistance properties of the used materials will be well known, so that there is no need for testing. If materials without documented fire resistance properties are used, a need for testing or evaluation by a test institution may be required.
The fire resistance requirements, including the reaction of the building articles (materials and elements) to fire as well as the fire resistance of the building elements, is primarily found in chapter 6 "Fire issues" in BR 95.
The requirements for a building article concerning the reaction to fire includes the properties of the building article, when subject to fire, as regards:

- Incombustibility
- Ignitability
- Heat emission
- Smoke emission and
- Protection of rearwards located, more combustible material.

The requirements for a building component concerning fire resistance includes the properties of the component, when subject to fire, as regards:

- Integrity
- Insulation and
- Load carrying capacity.

Testing for reaction to fire is conducted according to

- ISO 1182 for incombustibility
- ISO 5657 for ignitability
- DS/INSTA 412 for heat emission and smoke emission, and
- DS/INSTA 411 for fire protection capacity.

Testing for fire resistance is conducted according to

- DS 1051.1 for most components,
- DS 1051.2 for doors, and
- DS 1051.3 for glass panels.

Test results	Conditions regarding fire resistance has not been tested. Danisk Fire and Security Institute (DBI) has twice been requested to give an assessment based on information from Inexa about material and construction used in the bathroom. DBI has reported that it has not been possible to give such an assessment based on the provided information.
Evaluation criteria	The classification requirements for reaction to fire appear in DS 1057-1 (incombustibility), DS 1065-1 (class A and class B materials), and DS 1065-2 (class 1 and class 2 facings). The classification requirements for fire resistance appear in DS 1052.1 (building components exclusive doors) and DS 1052.2 (doors).
Evaluation	At present the situation regarding properties relating to fire is unclear. The problem should be solved before the product is marketed.
Remarks	Properties in relation to fire are assessed on a number of representative details of the construction and the building-in of the bathroom units, including the situation where 2 bathrooms are placed back to back as a vertical partition. The need for subsequent testing will be revealed during the evaluation. The MK test and approval conditions from ETA-Denmarks states the conditions on which requests about approval are treated. The building codes (BR 95) does not have any fire resistance requirements for floors in bathrooms.

Operation and maintenance

Susceptibility to soiling

Evaluation basis	Subjective evaluation of the possibilities for maintenance – by which is understood the possibility to perform replacement and renewal of materials, especially facing treatments including painting. The evaluation is based on knowledge of the materials in question, including their surface treatments, and on the following: - Materials that have to be maintained seldom are assessed better than materials that has to be maintained often. - Maintenance with commonly used methods and materials is generally assessed better than maintenance demanding special materials and/or methods. - Small extent of maintenance is assessed better than large extent.
Test results	The bathroom is supplied with finished surfaces of ceramic tiles that only require maintenance with long intervals. Tiles may be replaced after removing exixsting tiles by heating but special tile adhesive and joint mortar

are required as repairs according to the supplier shall be done with the same materials as originally used.

Evaluation criteria

Bad	acceptable	good	exellent
		Satisfaction of requirements, cfr. above	

Evaluation The possibilities for maintenance are in general assessed to be “good”, cfr. the band above where 2 out of 3 conditions are fulfilled. Replacement of tiles requires special products supplied by the manufacturer. The replacement process itself is not considered critical. However, replacement require skilled person certified to work with epoxy products and similar.

Repair and replacement

Evaluation basis The repairability and replaceability of floor and wall elements, sanitary components, installations and equipment is tested – in a full scale bathroom – by the replacement of elements, toilet bowl, washbasin, cistern, electrical installations and water installations. Repair and replacement shall as far as possible be performed according to the directions in the operation manual. Accessibility, time demand and requirement for special tools and materials are reported.

Test results Replacement of WC, wash basin etc is done using traditional methods, as these things are mounted on bolts inserted in/attached to the wall elements. Water installations are based on pipe in tube systems and replacement of the water carrying PEX pipes is consequently possible using traditional means.

Wall elements may be replaced individually but it requires a greater effort in a finished room as the ceiling needs to be demounted. Installations must not cross from element to element as this will make replacement of elements impossible.

Evaluation criteria It is evaluated to which extent the operation manual for the bathroom explains how repair and replacement shall be performed.

It is considered to be an advantage that a thorough operation manual with directions on repair and maintenance exists.

The evaluation of repairability and replaceability is based on accessability, time consumption and demands for special tools and materials.

Evaluation Ordinary replacement of WC, wash basin etc. is assessed to be easy and not different from what is done in traditional bathrooms.

Replacement of entire wall elements is difficult but possible. As replacement of elements is assessed to be fairly unusual this is considered to be satisfactory. Floor elements may only be replaced by demounting the entire room.

Tiles may be replaced but replacement is with the used adhesive assessed to be extremely difficult and total replacement of tiles can as a basis not be recommended. However, tiles have a very long service life even though fashion and trends might lead to an earlier replacement.
Replacement of tiles on the walls may as for ordinary walls be done by applying the new tiles on the existing ones. This is not possible on floors due to foor gully etc.

Appendix 1

Test program for Inexa bath room units

Transportation (ability to resist static and dynamic actions during transport)

Evaluation basis

a) The weight and volume of the elements must be determined (by measurement or information).
b) A dynamic load is applied to the elements, resembling that they are put down on a concrete support by a crane, i.e. with a speed of 2 m/minute. The load is applied to a corner or a side, depending on which is deemed to be the more unfavourable.
c) A dynamic load is applied to fixed floor and wall elements, resembling that they are bumped against a wall. An impact of a 1 kg steel ball with an energy of 20 Nm is applied to an edge or a corner, depending on which is deemed to be the more unfavourable.

Evaluation criteria

a) The weight and volume of the elements must be so limited, that they may be transported and assembled by two persons at most. According to the regulations of the National Labour Inspection (AT circular letter 12/1987) the maximum weight for elements intended for transport and assembling by one person is 50 kg, and for elements intended for transport and assembling by two persons 100 kg. It must be estimated, whether the volume permits carrying up the element in a staircase.
b) No repair-demanding damage may occur during the test.
c) No repair-demanding damage may occur during the test.

Comments

By testing according to b), the elements must be wrapped up as expected done in practice, e.g. transported on pallets and equipped with corner protectors.

Test specimen

For the test sufficient elements to make a whole bathroom (at least 1200 x 1200mm) is supplied. The elements are delivered as described under ”remarks”.

In the actual case it is proposed that testing is performed on elements to be used later for the full scale testing, (cfr. ”Durability and life expectancy”).

If the client foresee that elemnts might be damaged so they can not be used for subsequent testing, spare elements are delivered in a sufficient number.

Assembling (ability to resist static and dynamic actions during assembly)

Evaluation basis

a) A test assembly of elements is performed, where assembling is done more rough than prescribed, e.g. trying to twist thw elements during installation. Besides other unsuitable operations are performed, e.g. wrong installation or dismantling/correction of installed elements.
b) The finished floor in a full-scale test room assembled from elements is loaded by a static load of 2250 N through a 25mm steel mandrel.
c) It must be evaluated whether the performance of the finished bathroom is particularly sensitive to deviations in the work processes, e.g. dimension deviations and temperature conditions.
d) The bathroom is assembled on a supporting floor. After the assembling is finished the supporting floor is given a "simulated settlement of a joist floor" of 15 mm in one corner (This test is performed before the test for watertightness). If possible the supporting floor is afterwards reset so that the bathroom is brought into position again. Supplementary a floor element is projected over the support and tested with a static load of 2250 N.
e) It must be evaluated whether there are critical work operations demanding rigorous supervision.

Evaluation criteria

a) No repair-demanding damage may occur during the test.
b) No repair-demanding damage may occur during the test.
c) If the performance is assessed to be extra sensitive to relevant conditions, this should be reported.
d) The twisting of the bathroom must not cause damage, e.g. cracks or leaks.
e) If critical work operations are assessed to exist, this should be reported.

Test specimen

The above mentioned – cfr. *Transport* – elements are mounted on a substrate simulating a floor construction with wood beams (supplied by SBi).

If the client foresee that elements might be damaged so they can not be used for subsequent testing, spare elements are delivered in a sufficient number.

For tests with projecting parts extra elements shall be supplied for the construction of a ”large” floor element with joints.

Durability and life expectancy

1. Stability/durability

Evaluation basis

a) The floor of an assembled, full-scale bathroom is tested according to Nordtest method NT Build 230 (”Bathroom floors: Watertightness”). The test includes changing air humidity, alternating hot and cold water sprayed on the floor as well as static and dynamic loads applied to the floor. If it can be anticipated that the floor in larger bathrooms will be put together by more elements, the test specimen must include an element joint.
b) The walls of an assembled full-scale bathroom is tested according to Nordtest method NT Build 058 (”Walls in bathrooms: Watertightness and resistance to water and moisture”) and EOTA Guideline ETAG 003 (”Internal partition kits for use as non-loadbearing walls”). NT Build 058 includes actions of alternating hot and cold water, of high relative humidity in the air, and of mechanical loads on pipes and equipment. ETAG 003 includes action of dynamic load and will be modified for use in an assembled cabin, i.e. reduced height available so that the dynamic load must be applied in an alternative way, tailored to the actual space conditions.

Test specimen

A full scale bathroom – at least 1200 x 1200mm – is constructed in the laboratory.
The floor element shall at least comprise 2 elemnts assembled on site (in order to simulate joints in th efloor in a bigger bathroom) and should include an ingoing corner. The bathroom shall include wall hanged WC, wash basin and penetrations for pipes. The bathroom may be the same as used for *Assembling.*

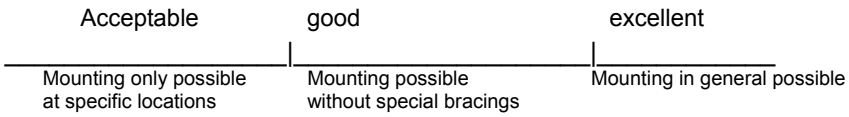
If only special arm rests and coat hooks are applicable these must

c) The carrying capacity of installation objects and late mounted arm supports and "coathooks", mounted according to the directions of the cabin vendor is tested as follows:
   - A lavatory bowl is loaded by a force of 4000 N, applied on the center of the bowl.
   - A wash basin is loaded by a force of 1500 N, applied in a distance of 420 mm from the wall surface or, for smaller wash basins, on the front edge.
   - An arm support is loaded with a force of 1000 N, applied where load is expected to act under normal use.
   - A "standard coathook" is loaded by a force of 100 N, applied at a distance of 150 mm from the wall surface.
   - For a wall hung lavatory bowl and for a washbasin supported by a mounting rack no testing is necessary.

d) For unknown material combinations, adhesion of tiles/facing is measured by a pull-off test on 100 x 100mm test specimens cut out of the underlay with corresponding tiling/facing.

Evaluation criteria

a) No damage or weakening of the floor construction must occur during the test. The construction/facing must be designated watertight.
b) No damage or weakening of the wall construction must occur during the test. The construction/facing must be designated watertight.
c) No damage must occur during the tests. The extent of the mounting possibilities may be judged according to the following band:



d) A pull-off strength of at least 0,15 N/mm^2 must be achieved.

Comments

The above Nordtest methods are normally considered to give a good impression of the watertightness after long-term use exposed to mechanical and hygrothermal actions, as the methods during a period apply an extended action to the constructions.
The Nordtest methods are normally used as the primary test in connection with the issuing of MK-approvals (national Danish approvals) for wet room constructions.
Testing according to c) is considered to cover interior design possibilities as far as the possibility to hang objects on the walls – cfr. the section "Applicability/flexibility for users".

be supplied from the manufacturer together with directions for the mounting.

Two tile cladded wall elements are supplied for cutting of tests specimen including necessary material to make a joint, (cfr. *Life expectancy*).

2. Life expectancy

So far, no general test methods exist for evaluation of the life expectancy.

Evaluation basis

Accelerated ageing is applied to individual materials/material combinations if their life expectancy is deemed to be uncertain. The test method must be chosen depending on the material/material combination first of all testing is foreseen to be performed on adhesive, sealing compounds and joint grout.

Ageing is so far limited to a heat ageing at 60 °C and subsequent assessment of the properties (the properties to be used as indicators are not yet decided but might for example be change in adhesion strength or change in colour).

Materials with unknown properties or materials assessed to be in risk by chemical attacks are tested by applying the suspected chemicals on the surface and let them act on the surface for 1 hour. The chemicals are chosen from the following list:

1. sodium hypochlorite, 2. acetic acid 32 %), 3. Iodine in ethanol (1 % solution). 4. Ammonia (24 %), 5. Detergent, 6. Olive oil, 7. Urine (5 % urea, 0.1 % hippuric acid, 0.01 % carbamide), 8. Black shoe polish, 9. petrol, 10. acetone.

Evaluation criteria

Evaluation may be performed based on information about and knowledge on the actual materials, including knowledge on, or evaluation of, physical and chemical compatibility of material combinations, and based on possible results of accelerated ageing tests with single materials or material combinations. In addition, conditions established during the above tests on "Stability/durability" may contribute.

Resistance to chemicals is evaluated subjectively based on a visual examination of the effect of the action.

bad	acceptable	good	excellent
Serious attack	Attack	Easy attack	Not influenced

The life expectancy for the materials of the bathroom must be evaluated to at least 20 years (except from possible surface treatment, elastic sealing compound and similar items, which do not participate in the primary sealing against penetration of moisture and water, and which normally demand frequent maintenance).

Test specimen

From the elements test specimens are cut for accelerated ageing at 60°C for 28 days.

The test specimens are meant for investigations of changes in the adhesion of tiles to the element and the cohesion of the parts of the element respectively.

Fire resistance requirements

Properties in relation to fire are assessed on basis of a number of representative details of batroom units built together with adjoining building elements including the situation where 2 units are placed back to back as a party wall. Any need for subsequent testing will be revealed as a result of the testing.

Evaluation basis

The fire resistance requirements of the Danish Building Regulations 1995 (BR 95) must be met. Normally the fire resistance properties of the used materials will be well known, so that there is no need for testing. If materials without documented fire resistance properties are used, a need for testing or evaluation by a test institution may be required.

Test specimen

SBi is not able to test/assess conditions relating to fire.

If so required SBi is willing to be responsible for getting assessment/testing done by a third party.

The fire resistance requirements, including the reaction of the building articles (materials and elements) to fire as well as the fire resistance of the building elements, is primarily found in chapter 6 "Fire issues" in BR 95.
The requirements for a building article concerning the reaction to fire includes the properties of the building article, when subject to fire, as regards:
– Incombustibility
– Ignitability
– Heat emission
– Smoke emission and
– Protection of rearwards located, more combustible material.

The requirements for a building component concerning fire resistance includes the properties of the component, when subject to fire, as regards:
– Integrity
– Insulation and
– Load carrying capacity.

Testing for reaction to fire is conducted according to
– ISO 1182 for incombustibility
– ISO 5657 for ignitability
– DS/INSTA 412 for heat emission and smoke emission, and
– DS/INSTA 411 for fire protection capacity.

Testing for fire resistance is conducted according to
– DS 1051.1 for most components,
– DS 1051.2 for doors, and
– DS 1051.3 for glass panels.

Evaluation criteria
The classification requirements for reaction to fire appear in DS 1057-1 (incombustibility), DS 1065-1 (class A and class B materials), and DS 1065-2 (class 1 and class 2 facings).
The classification requirements for fire resistance appear in DS 1052.1 (building components exclusive doors) and DS 1052.2 (doors).

Comments
The rules for consideration of applications for MK-approval of fire resistance properties appear in the "MK testing and approval terms" of ETA Danmark.
BR 95 contains no fire technical requirements to the flooring of a bathroom.

Operation and maintenance

1. Susceptibility to soiling and chalk
Not relevant as surfaces are chosen for each individual project.

2. Maintenance

Evaluation basis
Subjective evaluation of the possibilities for maintenance – by which is understood the possibility to perform replacement and renewal of materials.

Test specimen
No test specimen but the client must provide information about change and renovation of materials including methods and materials necessary.

rials, especially facing treatments including painting.
The evaluation is based on knowledge of the materials in question, including their surface treatments, and on the following:

- Materials that have to be maintained seldom are assessed better than materials that has to be maintained often.
- Maintenance with commonly used methods and materials is generally assessed better than maintenance demanding special materials and/or methods.
- Small extent of maintenance is assessed better than large extent.

Evaluation criteria

Bad | acceptable | good | exellent

Satisfaction of requirements, cfr. above

Comments
A short motivation for the overall evaluation must be given, e.g. large extent, special materials required, easy execution.

Repair and replacement

1. Complexity

Evaluation basis
The repairability and replaceability of floor and wall elements, sanitary components, installations and equipment is tested – in a full scale bathroom – by the replacement of elements, toilet bowl, washbasin, cistern, electrical installations and water installations. Repair and replacement shall as far as possible be performed according to the directions in the operation manual. Accessibility, time demand and requirement for special tools and materials is reported.

Evaluation criteria
It is evaluated to which extent the operation manual for the bathroom explains how repair and replacement shall be performed.
It is considered to be an advantage that a thorough operation manual with directions on repair and maintenance exists.
The evaluation of repairability and replaceability is based on accessability, time consumption and demands for special tools and materials.

Comments
Repair or replacement must lead to a result with the least possible deviation from the original surfaces etc.

Test specimen
Elements as substitute for those foreseen to be damaged by dismantling – otherwise it is proposed that the existing elements are reassembled. For WC, wash basin, cisterne etc. remounting of the same components is anticipated. The client supplies any necessary special tools, materials and maintenance manuals describing how rapair and change of elements/components is performed.

Applicability/flexibility for users

1. Layout
Not relevant as the property is project dependent.

2. Floor surface
Not relevant as the property is project dependent.

4. Heating and air exchange

Not relevant as the property is project dependent.

5. Acoustics

The acoustic requirements for bathrooms in new buildings are given in the Building Regulations as minimum requirements to airborne sound insulation, impact sound insulation and noise from technical installations measured in the finished building. According to present rules, alterations of party wall constructions and/or alterations of installations in existing buildings implies that the acoustic requirements of the current Building Regulations must be met by the constructions in question.

Evaluation basis

a) No testing, but subjective evaluation based primarily on experience values concerning airborne sound insulation, impact sound insulation and noise from technical installations.
b) If a better basis for decision is needed, it is in some cases possible to perform calculations of acoustic conditions according to the federal European standards in the DS/EN 12354 series.

Performance of such calculations will demand for input values for the sound insulation properties of the elements, e.g. the impact sound insulation of a floor construction or the additional insulation of an extra wall. These values may be available from the manufacturer, or they may be found by testing the elements, performing building acoustics laboratory measurements according to the DS/EN ISO 140 series.

Evaluation criteria

a) The evaluation includes an assessment of ceiling, wall and floor constructions, including the sound insulation properties of the materials, the distance to and clearance from surrounding building components, assembling methods, use of impact sound damping support or vibration absorbers, and sound absorbing material in cavities and shafts. For ventilation systems, an evaluation of provisions for reducing the sound transmission between dwellings via ventilation ducts is included. For water supply and sewer installations, an assessment of the used fittings and pipe materials as well as placing and fixing of pipes etc. is included. Taken together, an evaluation is made of whether the bathroom solution is expected to meet the acoustic requirements of the Building Regulations. Furthermore, an evaluation is made of whether comfort problems due to acoustic problems from the bathroom may be expected in the dwelling.
b) The results of the calculations must show that the actual acoustic requirements can be met.

Comments

Unless something else is agreed upon, the finished bathroom must meet the Building Regulations requirements for multi-storey dwellings.
During development of bathrooms assembled from elements, acoustic measurements may in special cases be performed in a mock-up including multiple rooms.
Check measurement of acoustic conditions should be performed in the building ready for occupation after finished installation of bathroom.

Test specimen

SBi is not able to test/assess conditions relating to acoustics.
If so required SBi is willing to be responsible for laboratory tests and in situ measurements in finished bathroom units/dwelllings done by a third party.

5. Illumination

6. Suitability for the disabled

Assessment of environmental issues

Assessment of environmental issues is performed by calculations using the computer programme Beat 2000.
The calculations are done on basis of the manufacturers information about the elemnts and their materials.

Test specimen

No test specimen but the client must provide information about the design of the floor and wall elements including types and quantities of adhesives, sealing compounds etc. used for the construction and assembling of the elements.
The results will be compared to a traditional ”heavy” bathroom with concrete floor (design of a reference bath room is proposed to be agreed with Byfornyelse Danmark).
The result will be given as the difference between the tested bathroom and the traditionak ”heavy” bathroom. In the calculations the influence of installations, WC, taps etc are left out as they are considered to contribute in the same way for both rooms.

dbur.dk
Danish Building and Urban Research

File no. 452-109

Department of
Building Design and Technology
P.O. Box 119
Dr. Neergaards Vej 15
DK-2970 Hørsholm
T +45 4586 5533
F +45 4586 7535
E info@by-og-byg.dk
W www.by-og-byg.dk

Giro 540-2786
CVR 64 14 93 18

For: SBS Byfornyelse
Ny Kongengade 15
1472 Kobenhavn K

testing based on overleaf conditions of a bath room unit assembled from prefabricated E info@by-og-byg.dk sandwich elements with tile cladding has been carried out according to the test methods W www.by-og-byg.dk described in "Test programme for Inexa batroom units" dated 200210 30.

The results of the test were:

Transport:

a) The biggest wall element-approximately 1.2 x 2.4 m - has a mass of 66.3 kg whereas the supplied floor element- approximately 1.1 x 1.3 m - has a mass of 120.4 kg. The volume of the biggest elements may cause problems when transportedin narrow places.
b) By lowering the elements onto a concrete floor - simulating elements delivered with a crane - no visible damage was observed.
c) Impacts with a 1 kg steel ball falling from 1020 mm (10Nm) on edge and surface respectively resulted in a dent in the surface and curling of the flange. When the steel ball fell from 1530 mm (15 Nm) it resulted in a dent in the surface and a dent and a damaged tile on the edge.

Assembling:

a) By test assembling no damages or other unfavorable conditions appeared.
b) By testing with 2250 N static load on the floor no visible failures was observed.
c) The performance of the bathroom unit is assessed not to be vulnerable to deviations in the assembling procedure.
d) A static load of 2250 N on a projected corner did not lead to measurable deflections or visible damages.
e) By assembling care shall be exercised to ensure that the sealant strip is placed correctly.

a) + b) After exposure to water there was no signs on penetration or deterioration.
c) Soft body impacts on the wall did not lead to damages on tiles or joints. The walls in the tested bathroom had no signs of leaks or deterioration. By supplementary testing of watertightness of joints between wall elements made with sealant strips alone no water penetration was observed.
d) No damages or weaknesses were observed after testing the load bearing capacity of wash basin, WC and arm rest. The possibility for mounting hooks etc. is assessed to be "good".
e) The adhesion of the tiles to the element was greater than 0.8 N/mm2 (0.8 MPa). (Breakage outside the test specimens).

Life expectancy. For adhesive heat aged at 60 °C for 28 days and exposed to a dynamic load of 1000 sinusoidal cycles varying between 0 and 0.3 N/mm^2 the adhesion/cohesion was above 1.4 MPa (Breakage outside the test specimens). The resistance against chemicals is for all the tested products (sodium hypochlorite, acetic acid 32%, ammonia 24%, Detergent, olive oil, urin) assessed to be "excellent"

Maintenance: All in all the maintenance possibilities are assessed to be "good".

Repair and replacement: Replacement of WC, wash basin etc. is done in a traditional manner as these are mounted on threaded rods inserted in the walls.

Elements may be changed individually but it will require quite an effort in a finished room as dismantling of ceiling and ceiling frame is necessary.

30.03.2004
Date

Project Engineer/Head of Department

The following terms and conditions shall apply to tests conducted and reports prepared thereon by the Danish Building and Urban Research

1. The Institute shall be liable to the client for all tests conducted and reports prepared in pursuance of the rules on liability for damages provided by Danish law subject to the limitations set out in (2)-(6) below.

2. The tests conducted and this report prepared thereon by the Institute are subject to the current standards of technology and science available to the Institute at the time of the testing. The Institute shall not incur any liability if, at a later stage, the standards of technology and science are proved to have been inadequate or faulty.

3. The Institute shall not be liable for any damage caused by one of the client's products-

   where the action causing the damage was committed by the client before the report on the testing of the product was issued by the Institute;

   where the product causing the damage was not specifically tested by the Institute, unless the client proves that the relevant product is identical to a product so tested, or

   where the damage is due to a particular feature of the product or to an application of the product which has either not been tested and described in the subsequent report, or which deviates from the description in the report of the particular product feature or of a possible product application.

4 The Institute disclaims any liability for damage arising on account of an opinion or statement submitted by the Institute provided that such opinion or statement is stated to have been based on an estimate.

5. Except for the instances set out in 2 - 4 above the Institute can be held liable if evidence is provided by the client that the damage was caused by an error or omission on the part of the Institute. Unless otherwise agreed the liability of the Institute for damage to property shall not exceed DKK 500,000 for any one damage. The Institute disclaims any liability for loss of production, consequential loss, loss of profit or any other indirect loss. The Institute shall not be held liable for any damage not notified in writing within three (3) years of the date of this report.

6. Where damages are claimed in the course of a legal action brought against the Institute extending beyond the limits of the liability of the Institute as set out in 2 - 5 above, the client shall proceed with the action if so requested by the Institute.

   The client shall indemnify the Institute for any liability imposed upon the Institute, and any expenditure otherwise incurred, exceeding the limits provided in 2 - 5 above for the liability of the Institute.

Please note that the Danish Building and Urban Research is not an approving authority. Consequently this test report must not be advertised or described as an Danish Building and Urban Research approval.

Client	SBS Byfornyelse Ny Kongensgade 15 1472 København K
Request	By letter from SBS Byfornyelse dated 2002-12-19, the offer frem Danish Building and Urban Research, dated 2002-10-30 concerning testing of bathroom was accepted.
Testing laboratory	Danish Building and Urban Research Department of Building Design and Technology
Responsible investigator	Senior researcher, civil engineer Erik Brandt
Report identification	File no.: 452-109
Purpose of the test	The testing comprises: • Testing of a full-scale bathroom built by prefabricated element according to the manufacturers directions for watertightness, resistance against dynamic loads and ability to mount fixtures, hooks etc. • Floor and wall elements for mass, resistance to dynamic loads under transport and assembling, adhesion of tiles to the substrate and supplementary tests of watertightness of joints. • Adhesive for testing resistance against dynamic loads. • Wall elements for supplementary testing of the watertightness of joints sealed with sealing strips alone.
Identification of test specimens	The tested elements are sandwich elements made with a core of mineral wool and with a galvanised steel plate on each side. On the surface facing the room the surface is clad with ceramic tiles glued to the steel plate with an epoxy adhesive. The joints between the wall elements are made with Dafakron 4 x 8 mm sealing strips. The tile adhesive is a 2 component adhesive Kleber 368-0100 (component A) and PUR Harter 385-0463A (component B) respectively.
Sampling	Elements and other materials for the testing were supplied by the client.
Test specimens	From the supplied elements a full-scale bathroom measuring 1.7 x 3.6 m has been made. The floor in the bathroom comprises 2 elements assembled on site with steel bolts from above, i.e. from the inside of the room. Afterwards the holes in the floor have been casted and the remaining tiles over the joint have been laid. Finally the joints have been filled with epoxy based joint grout. The floor is supplied with a floor gully and the walls with wash basin, wall hanged WC, penetrations for pipes and an arm rest for disabled. The jooint between floor and wall elements is made with a "gossip groove" under the wall elements allowing any water penetrating through the walls to come out again through an opening in the groove under the door - thereby reporting about a leak. Single elements used for testing of mass, resistance against dynamic load, resistance against chemicals etc. For supplementary testing of watertightness for sealant strips a corner consisting of the extra floor element and 2 single elements used for testing of mass etc. was used.

	For testing of resistance against dynamic load of tile adhesive 6 pair of tiles glued together with the supplied adhesive were made.
Test method	Nordtest metode NT Build 230 "Bathroom floors: Watertightness", 2nd edition, 1995-05. Nordtest metode NT Build 389 "Wall coverings: Waterproofing on small test pieces". Nordtest metode NT Build 058: "Walls in bathrooms: Watertightness and resistance to water and moisture". EOTA Guideline ETAG no. 003: "Internal partition kits for use as non-loadbearing walls". Other methods as described in "Test programme for Inexa bathroom units" dated 2002-10-30.
Time of delivery	The full-scale bathroom was made in December 2002 and other elements were delivered at the same time. After changing the design of the joint between floor and walls a new bathroom was made in May 2003. Adhesive for dynamic tetsing was supplied in July 2003.
Test period	Testing took place from December 2002 to September 2003.
Description of test procedure	At the first full-scale testing water penetrated at the joints between the elements leading to a change in design as agreed with the working group. The test for watertightness was repeated after the changes. At the visit of the working group after the test for watertightness had been finished, it was agreed to make a supplementary test of the joints without sealing compound in order to verify that the joints could be made watertight wit the sealant strip alone.
Deviations from normal procedure	For NT Build 230 and 058 the testing with varying humidity has not been performed as this was assessed to be without influence with the used combinations of materials. For EOTA Guideline ETAG 003 a modification of the loads has been made as the testing had to take place in a finished room with limited height to the ceiling and with corners and adjoining walls. For dynamic load with the steel ball the size of the load was changed from 20 Nm to 10/15 Nm. In agreement with Inexa the speed used for lowering the elements onto the floor was changed from 2 mlmin to 4 mlmin.
Test equipment	NT Build 230: Sandbag in leather in accordance with ASTM E-72 for application of dynamic load, SBI # 3969. Special made equipment for application of static load. The load is transferred through a steel rod with 25mm diameter. 7 Nozzles and other equipment for application of water as specified in the test method. NT Build 058 and 389: Control system and nozzles especially made for testing after these methods. EOTA Guideline ETAG 003: Bag with glass marbles in accordance with ISO 792:1988 "Vertical Building Components- Impact resistance Impact bodies and general test procedures", SBI # 3382. Remaining methods: Load cell, SBI # 3996, Amplifier, SBI # 4322, 50 mm dial meter, Universal test machine MTS, SBI # 3978.

Results and assessment

The results are given in the same order as they appear in the "Test programme for Inexa bathroom units" dated 2002-10-30.

Transport:

a) The biggest wall element - approximately 1.2 x 2.4 m - has a mass of 66.3 kg whereas the supplied floor element - approximately 1.1 x 1.3 m - has a mass of 120.4 kg, i.e. over the limits set by the National Labour Inspection (AT circular letter 12/1 987). The volume of the elements allow them to be carried by 2 persons. However, the biggest elements may cause problems when transported in narrow places.
b) By lowering the elements onto a concrete floor at a speed of 4 m/min no visible damage was observed.
c) Impacts with a 1 kg steel ball falling from 1020 mm (10Nm) on edge and surface respectively resulted in a dent in the surface and curling of the flange. When the steel ball fell from 1530 mm (15 Nm) it resulted in a dent in the surface and a dent and a damaged tile on the edge.

Assembling:

a) By test assembling no damages or other unfavourable conditions appeared.
b) By testing with 2250 N static load on the floor no visible failures was observed.
c) The performance of the bathroom unit is assessed not to be vulnerable to deviations in the assembling procedure.
d) A static load of 2250 N on a projected corner did not lead to measurable deflections or visible damages.
e) By assembling care shall be exercised to ensure that the sealant strip is placed correctly.

Stability/durability:

a) + b) After exposure to water there was no signs on penetration or deterioration.
c) Soft body impacts on the wall caused a minor, temporary deflection of the walls, but did not lead to damages on tiles or joints. The walls in the tested bathroom had no signs of leaks or deterioration. By supplementary testing of watertightness of joints between wall elements tightened with sealant strips alone no water penetration was observed.

Appendix 3 – Photos and drawings

Figure 1. Mounting of a wall element. The elements are mounted in a groove running along the edge of the floor eleme.

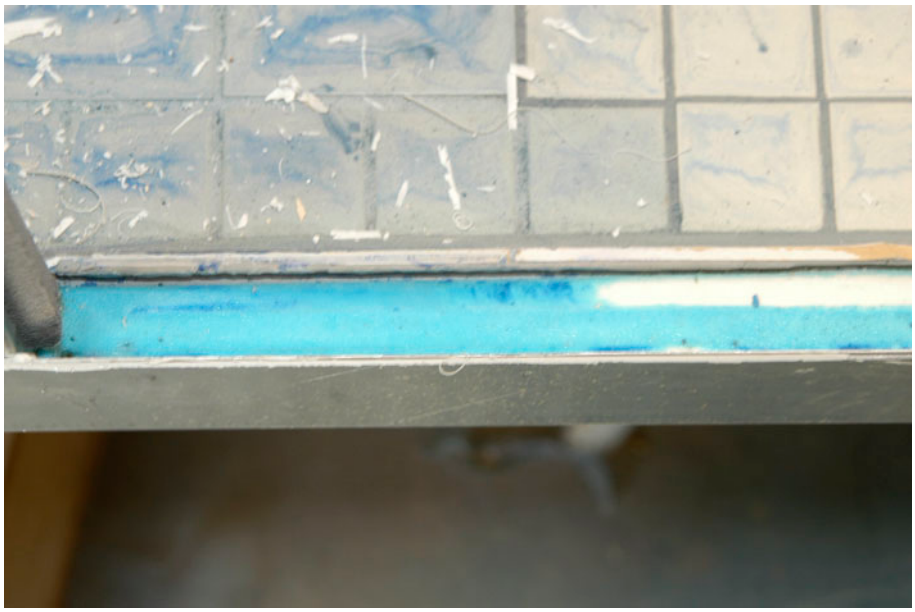


Figure 2. Groove along edge of floor element acting as substrate for wall elements.

Figure 3. Corner of wall element after impact against floor.

Figure 4. Corner of wall element after dynamic impact with steel ball (10 Nm).

Figure 5. Tile on edge of wall ellement after impact from steel ball (15 Nm).

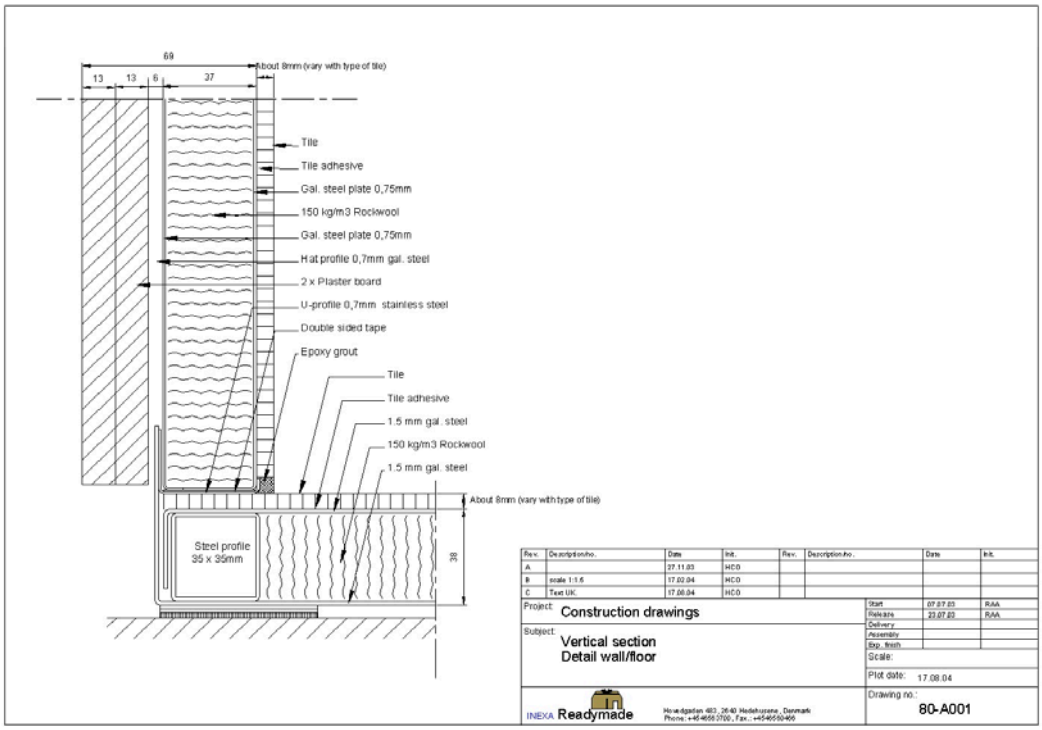


Figure 6.

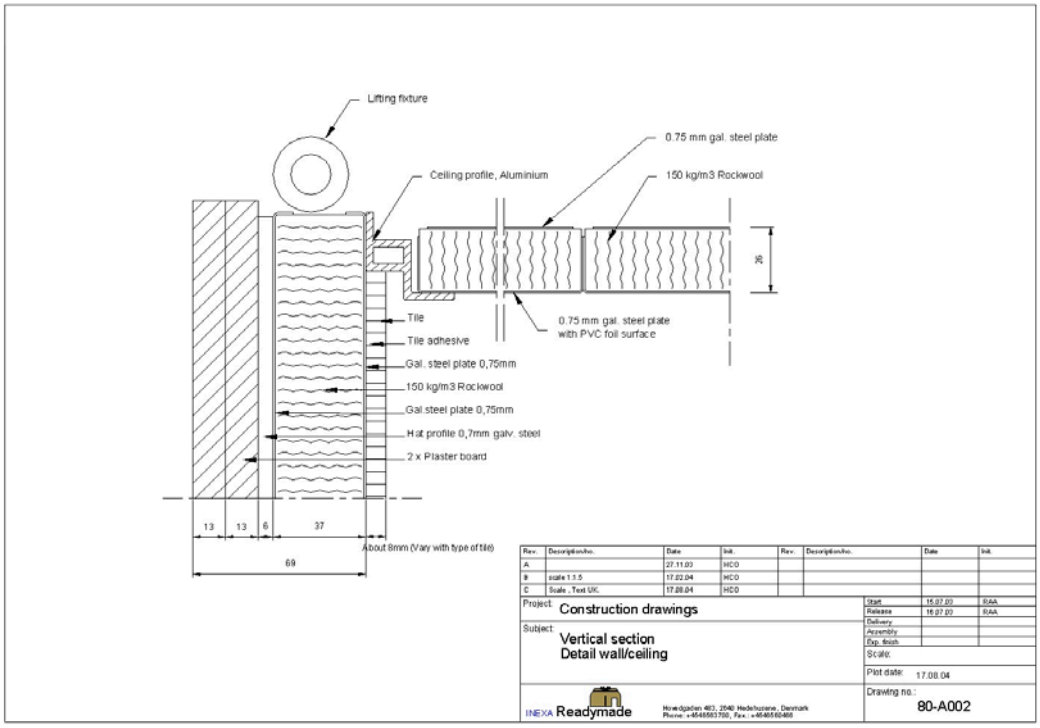


Figure 7.

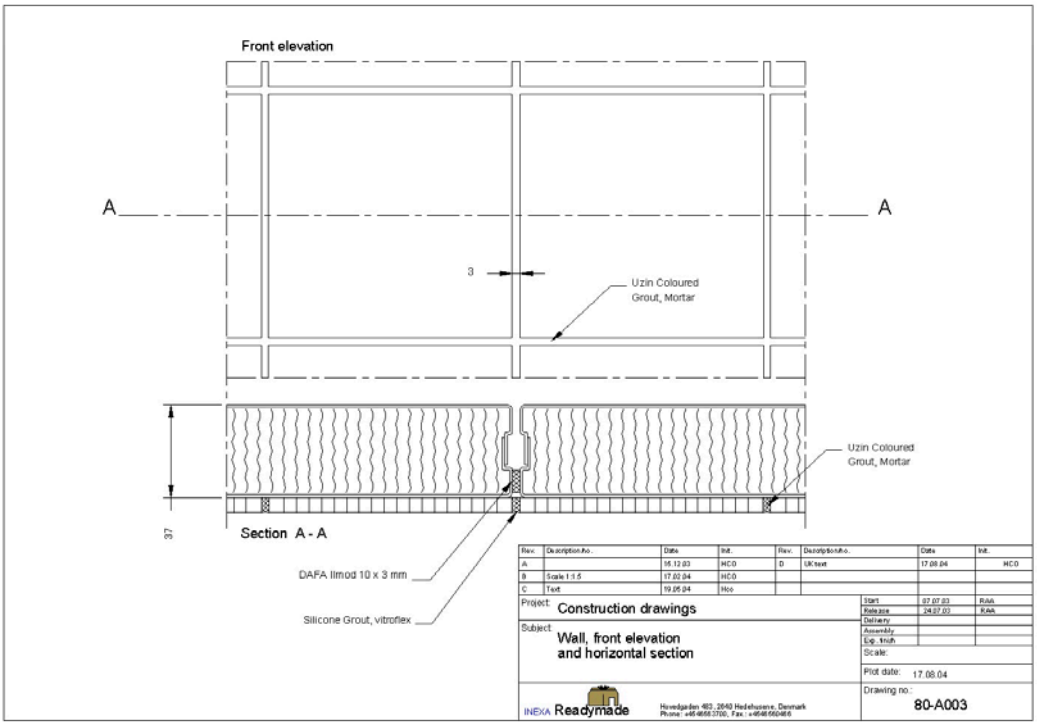


Figure 8.

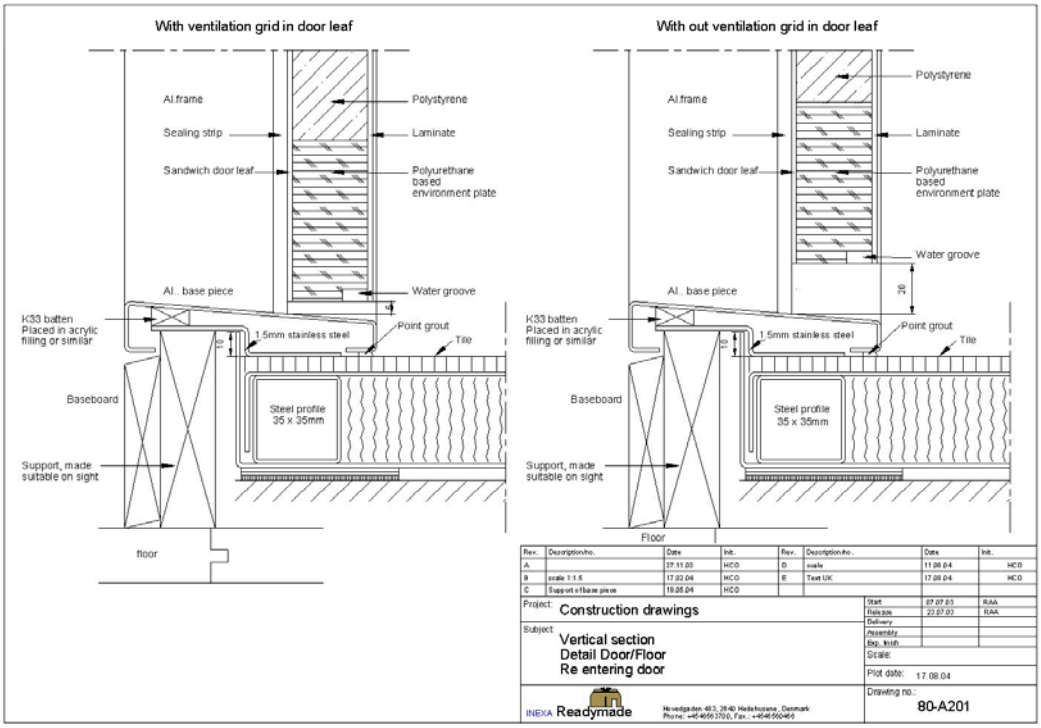


Figure 9.

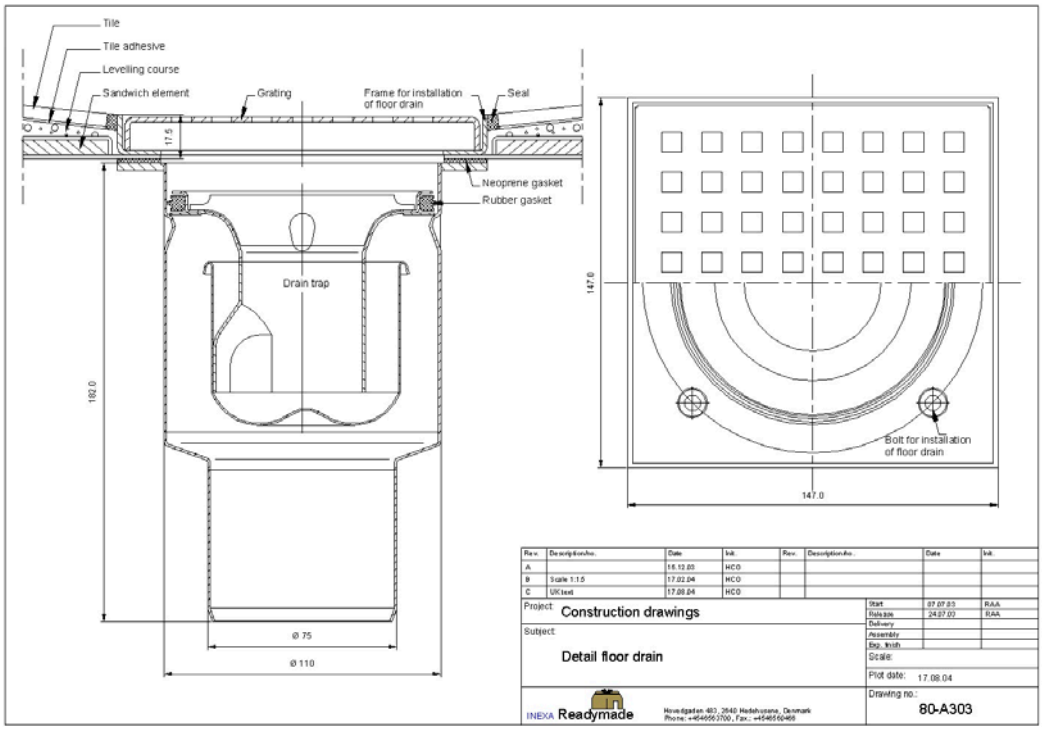

Tile
Tile adhesive
Levelling course
Sandwich element
Grating
Frame for installation of floor drain
Seal
17.5
Neoprene gasket
Rubber gasket
Drain trap
180.0
Ø 75
Ø 110
147.0
147.0
Bolt for installation of floor drain
Rev.
Description/ve..
Date
Init.
A
15.12.03
HCO
B
Scale 1:1.5
17.02.04
HCO
C
UK text
17.08.04
HCO
Project:
Construction drawings
Subject:
Detail floor drain
Start
07.07.03
RAA
Release
24.07.03
RAA
Delivery
Assembly
Eng. finish
Scale:
Plot date:
17.08.04
Drawing no.:
80-A303
INEXA Readymade

Figure 10.