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Concrete Containment Modeling and Management, Conmod

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ABSTRACT

The CONMOD project aims to create a system which will ensure that safety requirements for concrete containment structures will be up-held during the entire planned lifetime of plants and possibly during an extended lifetime. An important part of the project is to develop the application and understanding of Non-Destructive Testing (NDT) techniques for the assessment of conformity and condition of concrete reactor containments and to integrate this with state-of-the-art and developed Finite Element (FE) modelling techniques and analysis of structural behaviour. The objective being to create a diagnostic method for evaluation of ageing and degradation of concrete containments.

This method, the "CONMOD-methodology", will help in the planning and execution of actions that will improve safety in a manner which is optimal both in terms of economy and safety. The knowledge gained during the project will be presented in a handbook of best practice.

The decommissioned Barsebäck unit 1 reactor containment will be accessible for non-destructive examination throughout the duration of the project. Intrusive investigations will also be made including coring and material tests as a valuable complement to NDT.

KEY WORDS: Concrete containment, Non-Destructive Testing, Finite Element Analyses, Ageing, Degradation, Conformity, Defects, Ageing Management, Material Testing, CONMOD, Safety, Nuclear Power Plant

INTRODUCTION

The primary safety function of a containment is to provide the outermost barrier to the release of radioactive contamination to the surrounding environment during normal operation and during accidental situations taken into account by the design. It has therefore one of the most vital safety functions at a nuclear facility. The majority of the worlds' nuclear power plants were commissioned during the seventies and eighties. Approximately 60 % of the reactors are now more than 20 years old, while 20% are more than 30 years.

It is well known that concrete structures go through changes with time and that this can affect both ordinary reinforced and pre-stressed structures in unique ways. Many ageing processes are natural and can be expected, for example, creep and shrinkage of concrete and relaxation of pre-stressing tendons. There is however another category of ageing process or condition that is more often than not unpredictable, namely weaknesses caused by construction detailing and/or defects in the structure. The latter have shown to be capable of causing critical damage and/or unexpected deterioration.

For safety related structures at nuclear power plants, for example reactor containments, these unexpected ageing and deterioration processes can be particularly critical since they may have a damaging effect during the service life of a structure. In order to be able to detect critical damage and deterioration processes as early as possible during the lifespan of a containment it is vital to apply suitable inspection strategies and methods. Suitable inspection routines should be designed to detect and diagnose these but only visual accessible parts of the containment can be examined. In this process NDT has an important role to play.

The European Commission and a consortium consisting of four parties, Barsebäck Kraft (Sweden), EDF (France), Force Technology (Denmark) and Scanscot Technology (Sweden) have agreed upon a project named CONMOD. The project was started January 1st 2002 and will extend over a three year period. CONMOD is being financed by the European Commission and the partners, as well as the Swedish Nuclear Power Inspectorate (SKI) and Forsmark, OKG and Ringhals NPP in Sweden.

The objective of the CONMOD project is to create a system which will ensure that safety requirements for concrete reactor containments will be up-held during the entire planned lifetime of plants and possibly during an extended lifetime. This system will help in the planning and execution of actions that will improve safety in a manner which is optimal both in terms of economy and safety.

The system is built around working methods in which Non-Destructive Testing (NDT) and structural analysis based on Finite Element Analyses (FEA) are the corner stones. A key element in the CONMOD project is therefore to develop the application of NDT and FEA and to create a compatible and working interface between these disciplines. In

December 2002 a mock-up of a containment (MAEVA, France) was pressurized up to 1.5 times the design pressure. The results of this experimental pressure test will be used to validate the FEA software used in CONMOD.

The Barsebäck Nuclear Power Plant with its two units Barsebäck 1 and 2 is situated on the Swedish west coast. Construction of Barsebäck unit 1 was started in 1970 and the plant was in commercial service in 1975. Barsebäck unit 2 was in service two years later. The two reactors are in principal identical and are of BWR-type delivered by ASEA-Atom, each with a capacity of 615 MW. The containments consist of slip-formed pre-stressed concrete structures with embedded steel liners. Barsebäck unit 1 was decommissioned in 1999 in accordance with a government decision.

The NDT-methods and FEA-techniques will be tried and evaluated at the decommissioned reactor containment Barsebäck unit 1. Included in the project are also destructive material testing of drilled concrete cores from the containment wall, and examinations made directly at site. This material testing project will provide important complementary input to the non-destructive testing methods and an opportunity to validate the testing results as well as provide valuable general knowledge about effects of concrete ageing after almost 30 years in service.

The project benefits from the fact that the decommissioned Barsebäck unit 1 reactor containment will be accessible throughout the duration. The decommisioned containment will provide both generic and specific information in terms of long-term behaviour, effects of construction methods and NDT applications.

THE CONMOD-METHODOLOGY

As has been stated above, the objective of the project is to create a diagnostic method for evaluation of ageing and degradation of concrete containments. This includes obtaining relevant knowledge about the current state and behaviour of materials and structures, to locate, diagnose and manage critical areas or damaged zones, to optimize the maintenance and repair and to estimate the remaining safe lifetime of the containment. In addition to identify the remaining safety margins by taking into account, when necessary, the reference state, history of degradation/repair and estimation of degradation rate. During the first year of the project, a framework for this methodology was drawn up. This framework is built up of working procedures consisting of six steps as shown in Table 1.

Table 1: The CONMOD-methodology.

Step		Description	Result
1	**Inventoring, survey and initial analysis**	Inventoring and survey of existing documentations, such as; Regulations and Safety analysis report Calculations Visual inspections Service experience Leak-tightness tests Investigations Construction methods and details Generic knowledge and data. Visual inspection. Initial structural analysis based on nominal data from drawings etc. Sensitivity studies of vital input parameters.	Relevant events for different limit states (serviceability, ultimate, accidental) and belonging load conditions and acceptance criterias are identified. Critical areas and governing parameters with respect to leak-tightness and load bearing capacity are identified, which in turn forms the basis for planning inspections on site.
2	**Testing and examination**	Focused examinations based on the results in step 1. Examples of methods; Non-destructive testing Material testing Leak-tightness and structural integration test	The structural condition of the containment is determined. An evaluation is made of the future condition with regard to any relevant ageing processes and other factors, e.g. changes from design etc.
3	**Detailed evaluations and analysis**	Evaluation of test results from step 2. Investigations regarding the cause (phenomena) and extent of identified deviations and their influence (effect) on structural behaviour. If necessary, detailed structural analysis based on present, or estimated future, structural condition at chosen times.	Deviations are categorised and limits set regarding tolerable size and position. Ageing effects from construction to time of inspection are evaluated based on the data relating to time-dependant factors. The safety margins w.r.t. leak tightness and load bearing capacity at given points in time are determined. The remaining life-time of the containment is estimated.
4	**Maintenance plan**	Time intervals for future periodic inspections and execution of those actions that might be required to enhance safety, minimise ageing effects or strengthen are planned on the basis of the results of the investigations made in step 3. Updated structural models can be used to verify these actions.	On the basis of requirements w.r.t. safe operation of the plant an economically optimal maintenance plan is provided.
5	**Follow-up**	Periodic inspections are made in accordance with the maintenance plan	Actual behaviour with time is checked against predicted behaviour, e.g. actual ageing process and status.
6	**Actions**	Actions are put into effect at the planned times (where and if required). The condition, performance and compatibility of maintenance, e.g. protection or strengthening and possible secondary effects on the old concrete are checked.	Sufficient safety margins are achieved for the entire service life of the structure.

To achieve the goal of the project it is necessary to obtain information about material and structural characteristics and to identify their critical limits, through their evolution and the observable symptoms. Two important tools for this are non-destructive testing and structural analyses using the finite element method. In the project emphasis will be placed on developing the application and understanding of these techniques and, creating a working interface between them. The methods used must be capable of defining a healthy structure, whose state will be used as a reference for further diagnosis (state 1), to define the same structure at the beginning of its damage state, and the progress of the damage (state 2), and to define or predict the loss of capacity of this same structure (state 3), see Fig. 1.

Because of the size of the reactor containment it is not easy to detect all kinds of disorders and not practical to examine minutely each element of the structure, instead non-destructive testing has to be focused on the most important areas, the so called critical areas. One, of several (see step 1 in Table 1) methods to identify these areas is to perform structural analyses to identify the weakest parts regarding leak-tightness and load bearing capacity. As a valuable complement, and to validate the results from the NDT, intrusive methods and material testing can also be carried out.

State 1	State 2		State 3
Healthy state, as a reference	Appearance of defects	Evolution of deterioration	Loss of functional capacity

Limits to indentify Limits to indentify

Figure 1: States of structure to be identified.

In order to determine the consequences of the site-specific details, defects, ageing and deterioration established through inspections and other investigations, it is necessary to conduct structural analyses that take account of their influence on mechanical behaviour. Examples of phenomena that can alter the expected mechanical behaviour of a structure are presented in Table 2 below.

In the following paragraphs, the work during the first year of the project regarding non-destructive testing and structural analyses using the finite element method is presented. It is important, however, to bear in mind that non-destrucitve testing and finite element analysis are important, but are only two of several techniques to be used. Also, the importance of understanding and utilising the interaction and interface between these techniques must be emphasised.

Table 2: Example of phenomena that can alter the expected mechanical behaviour of reinforced concrete structures.

Material	Phenomena	Influence[1)]
Concrete	Leaching	Increase in porosity and permeability. Reduced compressiive strength.
	Drying	Drying under load will increase the creep. Variations in moisture levels may lead to differential shrinkage and micro-cracking.
	Sulphate attack	Expansion and cracking. Reduction in strength and of Young´s modulus.
	Acid attack	The hardened cement is dissolved and may be removed leaving exposed aggregates, e.g. at the surface.
	Salt crystallization	Alternate wetting and drying can cause salt crystallization in pores with resulting expansion, loss of strength and reduced elastic modulus.
	Alkali-silica reactions	Formation of alkali-silicate gel in the presence of high moisture leading to expansion and typically map-cracking. Leads mainly to reduction in tensile strength and elastic modulus. Large cracks can form due to expansion with consequent loss of bond to reinforcing and spallation in compressed zones.
	Freeze-thaw	Capillary water in the cement paste if frozen will cause expansion and cracking. A cumulative damage effect will take place with repeated freezing and thawing. Damage occurs typically in the form of surface scaling with loss of section and eventually bond to reinforcing. Freezing of the whole volume gives rise to reduction in Young´s modulus and strength. Spallation of concrete in compression zones.
	Elevated temperatures	Moderately high temperatures can lead to a loss of moisture which in turn will cause loss of strength and elastic modulus. The effects of exposure to temperatures above 250°C are significant.
	Irradiation	The true effects of irradiation alone are not well documented. Moderate levels of radiation are not thought to cause significant loss of strength.
	Abration, erosion and cavitation	Loss of material in affected zones.
	Creep	Delayed deformation. Reduction in pre-stressing force, see below.
	Shrinkage	Delayed deformation. Variation in shrinkage across section as well as prevented deformation may lead to changes in stresses. Reduction in pre-stressing force, see below.
	Fatigue	Failure occurs at lower stresses than the static compressive strength.
Reinforcement	Corrosion	A decrease in pH due to, carbonation of the concrete will cancel the corrosion-inhibiting effect of the normally high-alkaline environment. Chloride ingress is also a common cause of corrosion, sometimes severe with loss of reinforcement section and spalling of the concrete cover. Reduced bond to concrete. Complete loss of bar section can occur locally or large surfaces of concrete can delaminate from the reinforcement.
	Elevated temperatures	Reduced strength at high temperatures.
	Irradiation	Reduction in ductility and failure strain at high levels of radiation.
	Fatigue	Failure in steel at stresses below specified failure stress.
Pre-stressing tendons	Corrosion	Usually as local damage: point corrosion, stress corrosion or hydrogen embrittlement. Reduced sectional area or loss of prestress force/load bearing capacity.
	Elevated temperatures	Increase in tempature will reduce strength and influence relaxation and creep. No practical significance at moderate temperatures.
	Irradiation	Reduced ductility and failure strain at high levels of radiation.
	Fatigue	Cable rupture. Decreased bond (if grouted). Rupture at end anchorage.
	Relaxation	Reduction of pre-stressing force, see below.
	Reduction of pre-stressing force	Relaxation of steel and creep and shrinkage in concrete will reduce prestressing force.
Steel liner	Corrosion	Norrmally local damage with reduced sectional area and possibly even hole through liner.
	Elevated temperatures	High temperatures can reduce strength.
	Irradiation	Reduction in ductility and failure strain ac result from high levels of radiation.
	Fatigue	Rupture in steel at stresses lower than specified failure stress.
Construction related defects		
Direct effect	Void	Reduced sectional area. Reduced bond between reinforcement/pre-stressing tendon and concrete.
	Position of reinforcement	Reduced effective height.
	Cross-sectional area	Reduced sectional area or increased dead load or vice-versa.
	Material properties	For example low E-modulus.
	Pre-stressing force	Pre-stressing force applied too low.
	Reinforcement area	Reduced strength.
In-direct effect	Defects during design or construction	Initiate or accelerate deterioration processes.

1) Applies to direct effects if not otherwise stated.A condition or mechanism can also have an in-direct effect, for example by reducing the inherent protection against corrosion.

NON-DESTRUCTIVE TESTING

Non-destructive testing provides us with the means to obtain information about the structure, its components and materials. Destructive testing and intrusive investigations can also provide us with valuable information but these involve disturbance of the structure and cannot in practice be made to the same extent as NDT. NDT is by nature a more attractive alternative to some traditional destructive testing when dealing with structures of this size and importance. One does not exclude the other of course and the ideal situation is to combine the two. There has been a tendency to shy from NDT, with the arguments that it is unreliable and can be ambiguous, but this is surely not entirely true in many situations today. What is needed is a clearer definition of objectives, proven procedures to deal with these and improved communication between the involved parties, not least the ability to present results in a graphically understandable manner. With modern radiographic techniques we are able to quite easily penetrate walls of 1m and up to 1.5m thick to obtain information about relatively small details; to scan large surface areas using radar to map reinforcing and cable ducts; to use elegant acoustic techniques to describe the concrete structure and mechanical properties. Combining these techniques we obtain a full and descriptive picture of the internal structure and condition of large volumes of reinforced concrete in its undisturbed state in the structure.

Why check the structure if all appears well?

A concrete containment is in a passive state throughout its lifetime, in most cases never being exposed to challenging load conditions. The outer surface may be coated with a thick paint. Unlike other civil structures we can tell very little about the actual condition by visual examination alone. The structure may appear passive, but the materials and their interactions change during the entire lifetime. Results of tests made during construction, e.g. concrete sampling, may not be traceable several decades later. Since post-construction checks are rare and some on-site detail alterations can go un-documented, there is always a risk that conditions exist that will affect the behaviour of the structure and that these conditions remain unknown and their effects thereby remain unpredictable. The importance of the information obtained by for example non-destructive examinations will be very individual and site-specific. It is better to know than to assume and it is better to inspect than expect.

How do we go about inspecting this kind of structure?

The most important rule to follow is that inspections should focus on the site-specific conditions and obtaining this information is not simply achieved by random sampling of the structure. An effective approach to the problem, bearing in mind that the whole process of investigating and analysing a, containment involves a number of disciplines and their interaction, is to make inspections in stages:

- Preliminary investigation to obtain a first impression and evaluate the performance of techniques and practical issues
- Main investigation according to specific plans customised for the structure in question and including a basic survey without pre-conditions and a customised plan according to the particular needs at that site
- Special investigations at critical points or dealing with issues that have been identified as being critical

There is a practical problem and that is the time and resources available for inspection. For example one radiograph covering an area of 0.5 m2 may require 1.5 man-days, then we want to know where to look and what to look for. The inspection should encompass three aspects:

- The main issues at that site including those based on the preliminary investigation, the history and background information, the construction methods and details and finally the classical issues that might apply.
- The quality and conformity of the structure generally.
- Specific issues and their relevant parameters as identified by structural analyses etc.

The simplest form of NDT and use of this information is to check conformity, e.g. reinforcement size and position or wall thickness etc. The techniques available today, including processing software, are quite sophisticated allowing us to create three-dimensional diagrams showing the as-built structure and to compare with design. Even in these relatively simple cases we are unwise to rely on only one technique. In the example below (Fig.2) we see some results of radar and radiographic mapping of reinforcement and cable ducts in a containment wall.

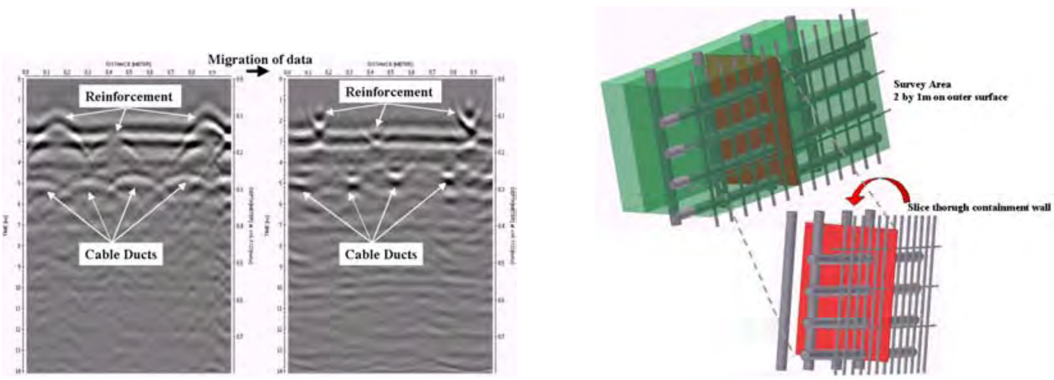


Figure 2: Radar scan of containment wall with raw data and processed data (left and right above) showing the position and depth of the reinforcement and pre-stressed cable ducts (left). Section diagram of the wall showing which cable ducts and reinforcing that will be detected by a vertical scan (right)

As stated above, the chances of making a successful NDT inspection are much greater if we know what we are looking for, and preferably have the opportunity to test the techniques and procedures on suitable models. This will not only help us to judge the expected performance beforehand, but also to choose method combinations that will reduce uncertainties. An example of a specific type of defect is shown below in Fig.3.

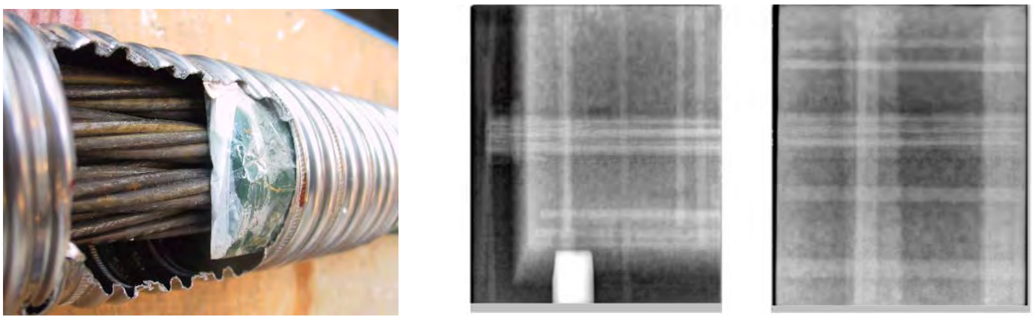


Figure 3: Model of cable duct with artificial air-filled and water-filled voids. The duct was cast in concrete and used to test the sensitivity of radiography in detecting the voids. The small air-filled void can be seen but the water-filled void is barely visible in 800mm thick concrete. The reinforcing and cables are clearly visible.

The type of problem case demonstrated in Fig.4 can be identified, e.g. indirectly during leak-tightness tests of the containment and by considering the background, e.g. when the problem was first observed. This might lead to intrusive investigations at some point to confirm theories. In this particular case the problem could be traced to construction methods, as could the expected size and type of similar defects if they should exist elsewhere in the structure. The methods chosen were proven on suitable models and used on site with success.

In the second example of this type we can consider typical pipe entries in the containment wall. Previous experience has shown that voids can occur above the pipe entries due to the method of construction used. We thus know where to look and what to look for and in addition what size of defect we can expect. The problem of choosing a suitable technique is quite simple and we can discount all techniques except high-energy radiography, having made preliminary tests on site.

These are examples of easily definable parameters and details that we are in a position to describe accurately and quickly with modern techniques. The data can be relatively easily used in parameter studies of the structural behaviour.

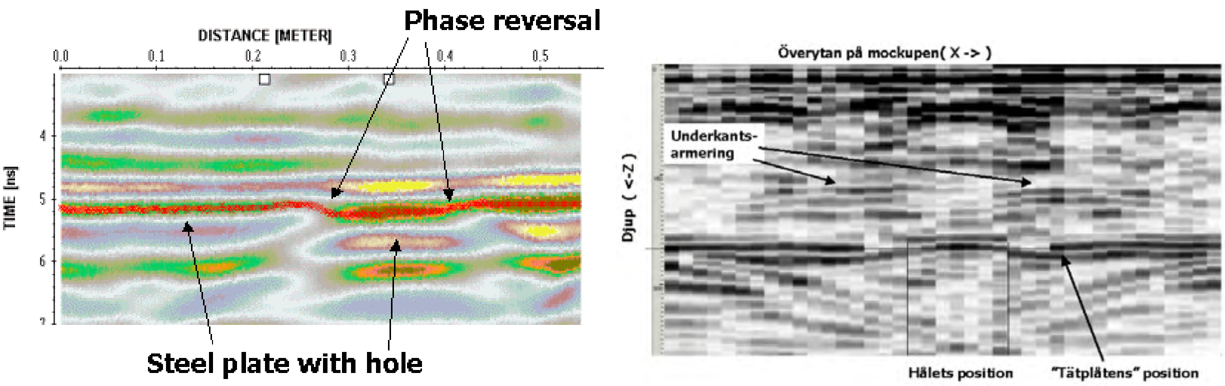
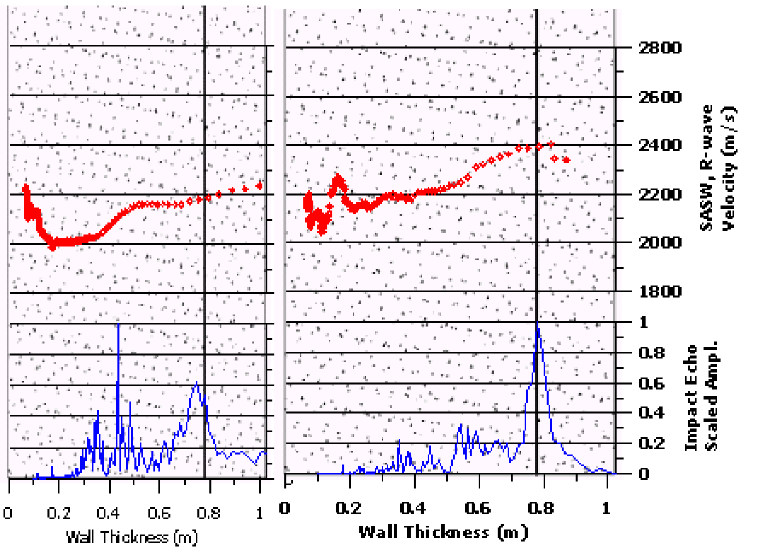


Figure 4: Steel liner embedded in concrete at a depth of 250mm. The liner has a 70mm diameter hole. Scans have been made using radar (upper diagram) and ultrasonic pulse echo (lower diagram). The hole is visible in both cases. Some reinforcement configurations can cause spurious indications in the radar scan and this technique is therefore not foolproof. By combining the two techniques it is possible to distinguish relevant from non-relevant indications.

Another type of problem we are faced with is in making an un-conditional survey of the structure to check the quality and detect defects if these should arise. This is more difficult as we do not know where defects might arise, what size they might be or what orientation they may have. Neither have we considered what is and is not acceptable, given that most concrete structures cannot be expected to be perfect. A compromise has therefore to be reached and a method (methods) chosen that will reveal if everything is as it should be, or if there is reason to suspect that something is wrong. We rely therefore on being able to predict the response of the structure or part thereof to the stimulation we provide, for example, be it from radar scanning or the echo response to a hammer impact. Predicting the response relies on understanding the internal geometry of the concrete and its boundary conditions, and here we rely on non-destructive testing to establish this and it becomes apparent how dependant we are on method combination and interplay. The problem does not end here, as we must decide if a suspected anomaly is of any consequence or not. An example of this type of problem is shown in Fig.5. If we can relate the anomaly to a known or suspected effect, for example, of construction method then we are in a better position to judge if they constitute a problem or not. We may never be able to answer some questions of this type fully by non-destructive testing alone and may have to go one step further and remove cores for analysis. Emphasis is placed on finding and characterizing systematic effects rather than random deviations, as the former can normally be related to other factors such as construction methods and effects of environment and can thus be predicted and quantified more accurately.

These are some practical examples of the use of NDT on a containment structure. Some of these are very specific and to the outside observer it may be difficult to relate them to the behaviour of the structure as a whole. They do however demonstrate that NDT can be used to find out detailed information with considerable accuracy, and some of these details are in fact critical, e.g. the integrity of the steel liner. Apart from this type of information we are able to accumulate huge amounts of data such as the dynamic elastic modulus of the concrete and variations thereof, the thickness of sections, bond between concrete and steel liner and systematic concrete defects and hidden construction details. All of this information can be dealt with in the structural modelling of behaviour at a local and global level. Combining NDT and material tests with site studies including environment conditions we will be in a position to understand the time-dependant factors and how this may have affected the structure since construction and what to expect in the future.



The normal response should show a dominant P-wave echo at the liner, but in the left figure we can see that the dominant echo arises some 430mm from the surface. The dispersion curve should be straight, but diverges at wavelengths corresponding to the internal echo depth. The R-wave velocity should be 56% of the P-wave velocity but there is some discrepancy. In this case there is good reason to suspect some kind of internal anomaly, but this information alone is not sufficient to describe its character and size. Compare with the result from another position (right figure). In this case the dispersion curve is reasonably straight up to wavelengths of about 500mm after which the velocity of the Rayleigh waves increases to a maximum of about 2400m/s. The compression wave echo from the liner is in this case dominant and no significant reflectors appear between the surface and the liner.

Figure 5: Impact response showing compression (P) wave echoes (blue) and Rayleigh (R) wave dispersion (red) in the 1m thick containment wall with a steel liner embedded (thick black line).

STRUCTURAL ANALYSES

Structural analyses will be carried out in different phases of the project;

- initial analyses to understand the structural behaviour and to find critical areas and governing parameters regarding leak-tightness and load bearing capacity (step 1 in the CONMOD-methodology, see Table 1)
- detailed analyses to take into consideration the influence on mechanical behaviour from unexpected ageing, defects and deterioration (step 3 in the CONMOD-methodology, see Table 1)
- analyses to verify safety-enhancing actions (if any) (step 4 in the CONMOD-methodology, see Table 1)

During the first year of the project, structural analyses of Barsebäck unit 1 containment have been executed in order to get a good understanding of the structural response due to overpressurization and thus also to identify critical areas and governing parameters regarding leak-tightness and load bearing capacity. Global axisymmetric FEA-models of the containment structure have been generated together with additional local models of pipe entries and hatches, as shown in Figure 6. The identification of critical areas and governing parameters will form one of the basis for planning of investigations and testing at site. To implement the information gained during investigation and testing and to study the influence of detected ageing, defects and deterioration on the structural behaviour, detailed three-dimensional models are used (Figure 9). In addition, safety-enhancing strengthening can be approved by updating the structural models.

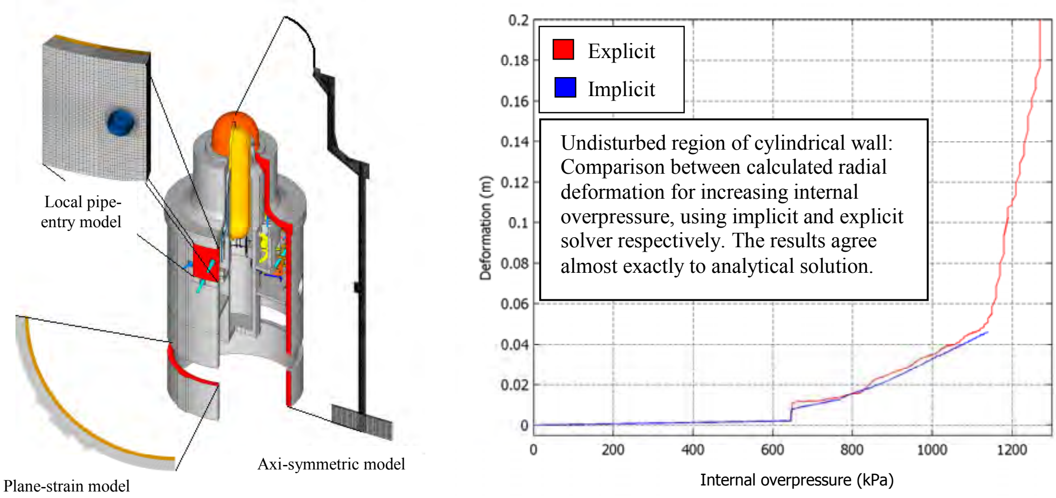


Figure 6: Structural models used during the initial analyses (left). Comparison of different solver techniques (right).

The steel liner in the Swedish containments is embedded in the concrete approximately 25 cm from the inner surface, to provide the liner with protection from mechanical damage. In order to describe the interaction and bonding effect between the steel liner and concrete, contact algorithms have been introduced in the model. In these algorithms the coefficient of friction is defined between the surfaces. Using an identical approach between other steel structural elements and concrete, it has been possible to more in detail calculate and evaluate the stress state at hatches and pipe-entries through the containment wall, see Figure 7. In light of the fact that pipe-entries are known to be critical with regard to leak-tightness, it is of great value to have techniques which can simulate numerically the effects of eventual deficiencies and degradation effects in these areas.

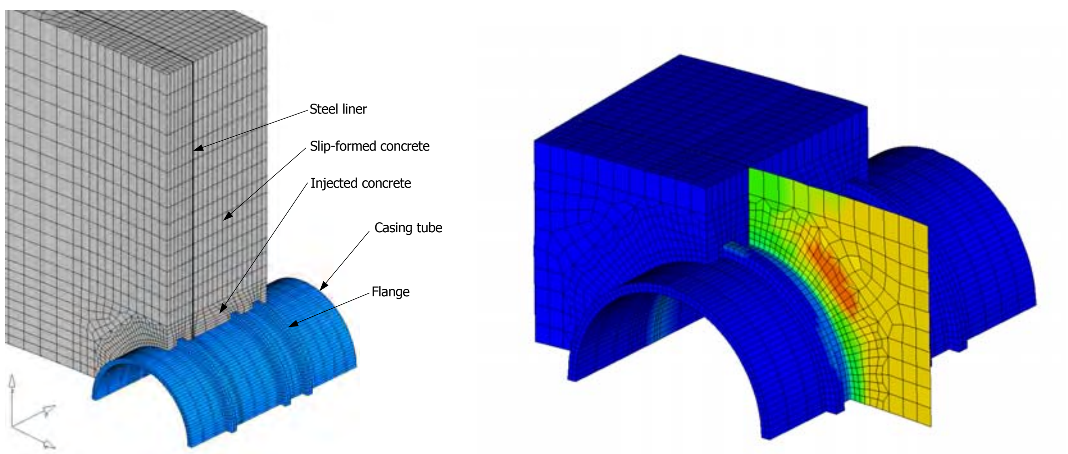


Figure 7: Cross-section through a local FEA-model (left) of a pipe-entry and the stress state in the steel liner (right).

It is also vital to ensure that the methods applied for advanced structural analyses can be validated. The FEA programmes and applied methods in CONMOD will be validated against results gained from the pressure test of the MAEVA model compartment, representing a typical cylindrical wall section of a PWR containment. Also, comparison of analysis results using different constitutive models and solver techniques increases the confidence, see Figure 6.

Focus in the analysis work so far in the project has been on identifying critical areas and governing parameters with regard to leak tightness and load-bearing capacity. In addition, studies have been performed in order to determine the sensitivity of the structural response to variation of governing parameters (Figure 8). When doing sensitivity studies, the number of calculations to be carried out increase rapidly. Therefore, it have been of vital importance to develop analyses techniques that minimize the executional runtimes.

The results from the initial structural analyses will form one of the bases for planning non-destructive testing at site. Other important basis for planning the testing include inventoring of all conditions and design requirements for the structure, applied building methods, notes about deviations during construction, visual inspections at site and service experience.

In step 3 of the CONMOD-methodology, techniques will be implemented to take into consideration the influence on mechanical behaviour from unexpected ageing, defects and deterioration. This will be made using detailed global (Figure 9) and local (Figure 7) three-dimensional FEA-models. Also, emphasis will be put on interpretation of testing data (from step 2) to characteristic values that will used in the structural analyses.

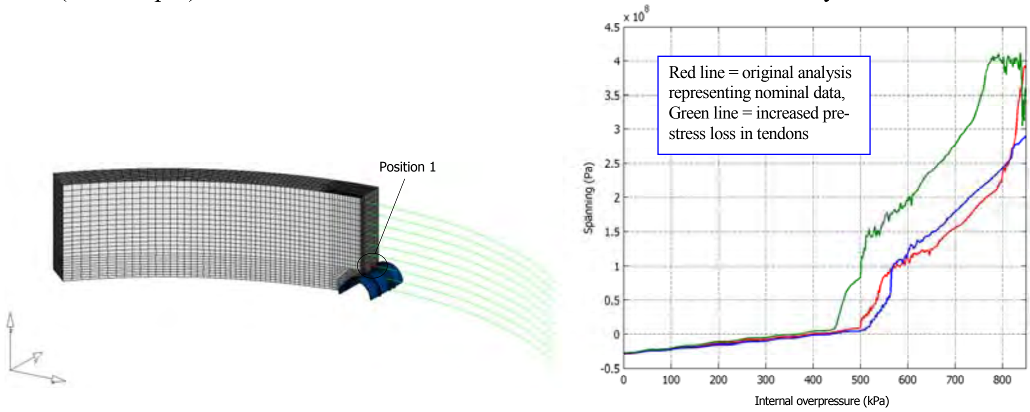


Figure 8: Example of sensitivity analysis showing area near pipe-entry. Stresses in steel-liner.

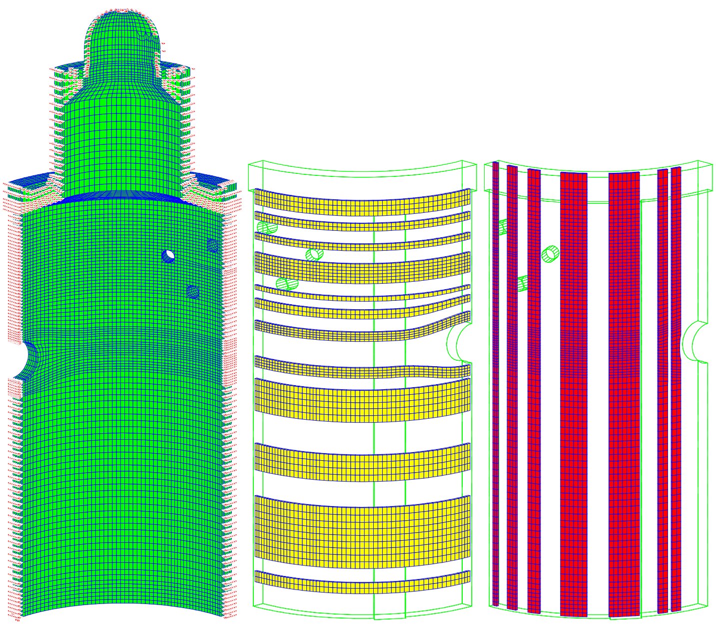


Figure 9: Global three-dimensional FEA-model representing a quarter of a containment (left). Prestressed tendons are grouped to facilitate construction, both in horizontal (yellow elements) and vertical (red elements) directions.

CONCLUSION

After only one year since work began the project is still at an early stage and many interesting questions remain to be dealt with. The first year has involved a lot of preparatory work, which is without doubt essential to forming a plan for what will be a major, multi-disciplinary exercise. A number of important issues have already been identified from theoretical studies as well as in the first site investigations including the back-ground history of the structure. All of this in preparation for the main investigation which will involve a series of intensive site inspections and material analysis synchronised with structural analyses at various levels and covering a range of issues. This is a considerable challenge as we are not dealing with simple measurement and single parameter studies but a complicated combination of sometimes diffuse information which must be dealt with in a practical and scientifically correct manner.

The greatest challenge lies ahead as we are not only faced with the problem of structural condition at this time but also how this will change with time. The project is unique and interesting and has an element of credibility perhaps not found in many “similar” studies, as we are dealing with and have at our disposal a real containment structure which has existed under real conditions for almost an entire design lifetime.