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IMPLEMENTING THE STANDARDS AND REGULATIONS VIEW ON BUILDINGS

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Abstract

This paper presents an approach to achieve computer aided compliance checking of building designs against building regulations.

. Introduction

Compliance checking of building designs is required to enforce standards related to safety, health, nvironment and economy (e.g. energy consumption). In the Netherlands, like in most countries, is required that a detailed design is submitted to the local building authorities to obtain a building ermit. A building permit can only be obtained if the building design meets the requirements of the ublic authorities, as laid down in numerous regulations and standards[1]. Figure 1 shows an IDEF- diagram of a global standards and regulation view on the building process.

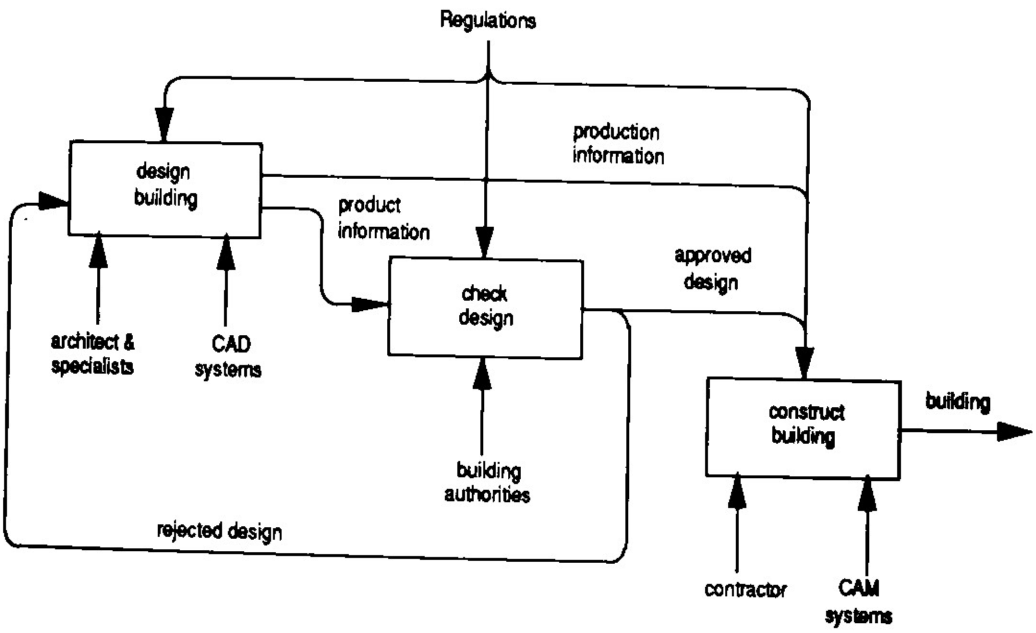

Figure 1. Global function model of the building process

gure 1 illustrates the fact that during the design process architects and specialists use computer stems, but the people who do the compliance checking not. Firstly because no computer plementation of major parts of the standards and regulations has been reported and secondly cause there is no agreed neutral format for the exchange of building data in a multi-vendor vironment. For that reasons the information transfer from the designer to the building authorities till done in a traditional way, e.g. through technical drawings and the like. Also the information hange from the building authorities to the designers and engineers has not undergone much nge. In the Netherlands, like in most other countries, several attempts have been made to end the idea of electronic data interchange also to the compliance checking process, but these rts never had much influence nor results.

the Netherlands more than 400 different codes of practise, regulations and standards are related to the Building and truction industries.

2. The product modelling approach

In this paper we propose a new approach to the process of computer aided compliance checking (CACC), based on the usage of so called product models. Our approach requires (1) an information model of the building in the 'As Designed' stage, that can serve as a standardised (neutral) format for product data exchange and (2) an information model of the building regulations. The paper discusses two alternative approaches.

The first approach is, to allow the detailed building design (As Designed) to be submitted in the standardised computer format and to provide the building authorities with CACC-systems that accept this data models as their input. This approach requires a complete implementation of the building regulations in the CACC-systems. Whether the CAD/CAE-systems in use have any knowledge about regulations or not, is not important. The advantage of this approach is that it might be possible to allow the CACC-systems to be based on different sets of regulations, e.g. to check the same design against the regulations of different countries, which might become important in Europe after 1992.

The second approach is to transfer knowledge included in the standards and regulations upstream to the designers and engineers, e.g. to implement (parts of) the regulations in the systems and/or information models used by the CAD/CAE-systems. When it is possible to provide designers and engineers with systems that can do on-line compliance checking, much could be gained.

The paper presents some of the results obtained so far in our research on the application of product modelling in the compliance checking process. In section 3 we will present a part of a product model of a family house, which we use as an illustration of the ideas presented. Section 4 discusses the content and structure of the building regulations and section 5 shows a part of a producttype model which includes some requirements. Finally section 6 gives a brief summary and the main conclusions.

3. Kernel of the House model

A product model is an information model of a specific product. Here we concentrate on family houses, so a product model is a model of a particular house. A product model can be developed for each individual house that we have to build, or, as an alternative, we can develop a so called producttype model, which is an information model of a class of products [8], in this case a model of the class of products called family houses. A product model is then an instantiation of a producttype model. At TNO-IBBC we are working on the development of a producttype model for buildings used for housing, called the *House model*. In this section we will describe the kernel of the model.

In general there are two ways to look at a building. One way is to look at a building as a spatial system. This is the spatial view, where we see the building as a collection of space parts (rooms, passages, etc). The other way is to look at a building as a building-technical system (the building-technical view), consisting of building elements (floors, walls, columns, ...). The House model starts with the observation that we can describe the spatial system as a hierarchy of spaces. However we cannot look at the spatial system without looking at the building-technical system, merely because the elements from the building technical system, like the floors and walls, make up the spaces in a building. In the House model we want to integrate both views. This can be accomplished by introducing an artificial entity called 'space part delimiter'. Every space part is delimited by space part delimiters which belong only to that space part. A space part delimiter can be formed by a separation construction. To the space part delimiters we can attach information that is only relevant for one side of a separation construction, i.e. the points for electricity supply connections, switches, and the like, e.g. information that is only relevant for that particular space part. To the separation construction we attach the information that is not only relevant for one side, but for both sides of the separation construction. Here we can think about holes for doors and windows. This kind of information is not only relevant for one space part, but for more. A door

›r instance is a connection between two space parts. This kernel of the House model is sketched
ı NIAM[2] in figure 2.

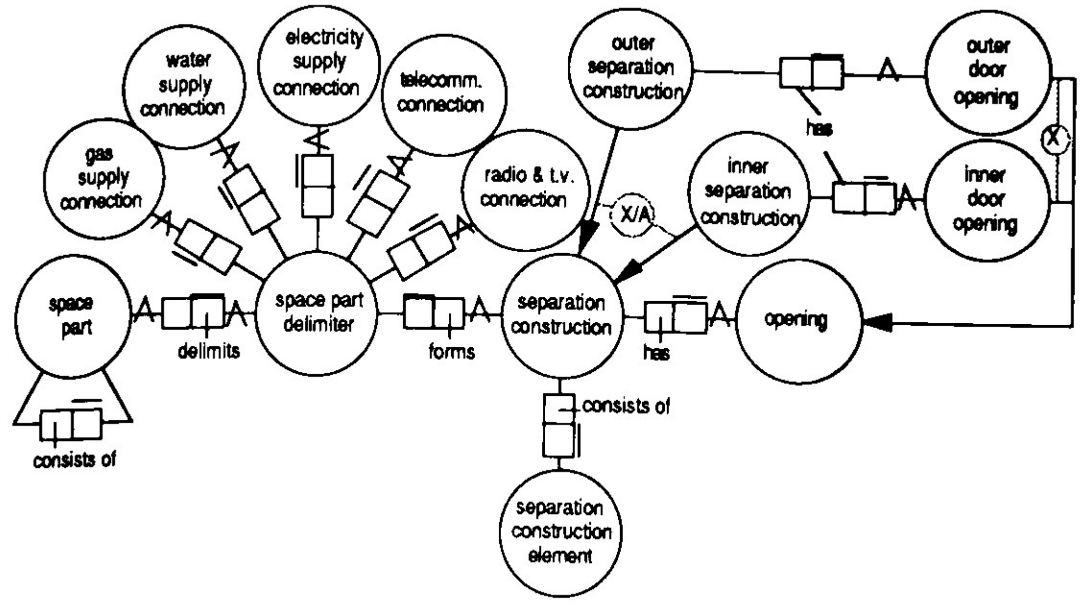

Figure 2. Kernel of the House model

ith this kernel we are able to model houses. We can make all kinds of specializations of the jecttypes. Specializations of space parts are for instance: house space, floor space, room space, throom space, passage space, etc. The specialization of the space part delimiters goes in parallel that of the space parts. The specialization of the separation constructions only introduces the jecttypes vertical, horizontal and sliding inner and outer separation construction. With these cializations we are able to model houses on the required semantic level.

Building regulations

Building regulations in the Netherlands.

he Netherlands we have an hierarchy of standards and regulations that are applicable to houses. the top level we start with the Housing law. Under the Housing law we find the Building by-s and the overall Building regulations called the "Bouwbesluit" (BB). The BB contains the ulations that have to do with the general building and living technical aspects of houses. All the er aspects that have to be considered before a building permit can be given, are contained in the lding by-laws. Under the BB we find the national standards and the preconditions for nections for gas, electricity and water.

building regulations currently under consideration are only those mentioned in the BB. The earch concentrates on modelling the standards and provisions in the BB and the underlying ılations. The BB consists of functional requirements. The individual requirements consists nly of two parts: (1) why the requirement is given and (2) the requirement itself. The irement itself is made up of a condition part, a subject, what is demanded of the subject and a of determining whether or not the requirement is met. Some simple examples of the semantic l of the requirements included in the BB are:

42.1 The house must contain at least one place to wash oneself, which has been realized by ns of a separate bathroom.

42.3 The bathroom should contain a wash stand, which is connected to the waste water nage system. Over the wash stand there should be a water tap, that is connected to the water ly system.

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sens Information Analysis Method [13]. NIAM is the informal modelling language we use. For the detailed models we ISO-STEP and use Express.

4.2 Computer models of building regulations.

Research on building regulations and standards has been going on for quite some time now [3, 4, 5, 6]. Harris and Wright [5] distinguish three kinds of standards: performance, prescriptive and procedural standards. Performance standards state that a building or a subsystem must function in a specific way. Prescriptive standards place strict limits on the size and content of building materials, rooms, etc. Procedural standards define rules for measuring quantities in the building to be designed, or for analysis. Each standard then exists of a number of provisions, in our national situation these are articles and sub-articles.

Most of the work that has been done so far uses a number of basic elements to describe a standard. These basic elements are: data items, decision tables, information networks and outlines. The data items are the variables occuring in a standard. The data can be either terminal, intermediate or input data. Decision tables represent the logic to be used to determine the values of the data items. The information network shows which data have to be evaluated prior to the evaluation of a specific data item. The outline is the way the provisions in a standard are organized [6]. Other work done at TNO, tried to deal with the same problem as Fenves [3], namely the mutual consistency of the standards. In this project the researchers developed a grammar for a part of the Dutch building regulations. Other research tried to apply rule-based expert systems technology, which resulted in an actual implementation of our national fire regulations.

In our research project we are not concentrating on the development of grammars for building regulations, but on the implementation of the standards and regulations view on buildings, e.g. on the following two questions:

(1) How can we extract the information required by the building authorities out of the product model, or:
(2) How can we model the requirements presented in the standards and regulations?

5. Extracting the regulations view and modelling the requirements

All of the research projects mentioned above only considered the regulations itself, with the aim of supporting the writers of standards, and did almost nothing to the interface with CAD systems. Exceptions come from the former National Bureau of Standards [7] and of TNO [11].

The first aim of our research project is to map the semantics of the product model in the 'As Designed' stage on the semantics of the standards and regulations. This is necessary because the BB is rather global and does in most cases not refer to specific entities included in the product model. The BB is for instance only interested in global functions. Where a designer distinguishes a sleeping and a living room, the BB calls both rooms 'residing spaces'. The BB is also not interested in details. The regulation view that can be extracted from the product model is a 'simplified' product model, where several attributes are left out and entities have been renamed. The regulation view can thus be deducted from the product model by mapping the entities of the product model on entities from the regulations view, possibly by a simple generalization/specialization structure.

The second aim of our research is to model the requirements of the building regulations and make them part of the producttype model. To incorporate knowledge contained in the building regulations in the producttype model we let the objecttypes from the House model refer to the regulations that are applicable. This is done through constructs that are found in the GARM [10, 12].

The GARM proposes to distinguish each object (called Product Definition Unit) in at least two states: the As Required state, called FU, from Functional Unit and the As Designed state, called Technical Solution (TS). The FU's collect all the requirements as they come from different sources (client, regulations, company resources, etc). The GARM also proposes a hierarchical decomposition that closely follows the actual design process, namely a so called FU-TS decomposition. Each FU can be satisfied by one or more alternative TS's. Sometimes a TS can be bought, sometimes not. If a TS has to be designed further, it decomposes into a set of related FU's from a lower order. The advantage from this construct in our case is (1) that there is a place where functional requirements can be modelled, (2) that the same hierarchical decomposition is also used in the Building regulations, (3) that there is a place where the actual characteristics of a

S can be modelled and (4) that it is easy to match the requirements collected in the FU's to the iaracteristics collected in the TS's.

igure 3 shows a small part of the House model. It shows that the FU 'Place to wash oneself' is a pace part' and thus inherits the kernel entities of figure 2. It shows also that there may be fferent alternative TS's, but the TS 'Bathroom' is required by art. 42.1 of the BB. Next comes e decomposition of the TS 'Bathroom' in: 'Wash stand place' (required by art. 42.3), 'Waste ater outlet', 'Tap' and 'Water supply connection' and of course many other entities that are left it. The relations between the entities follow from art. 42.3.

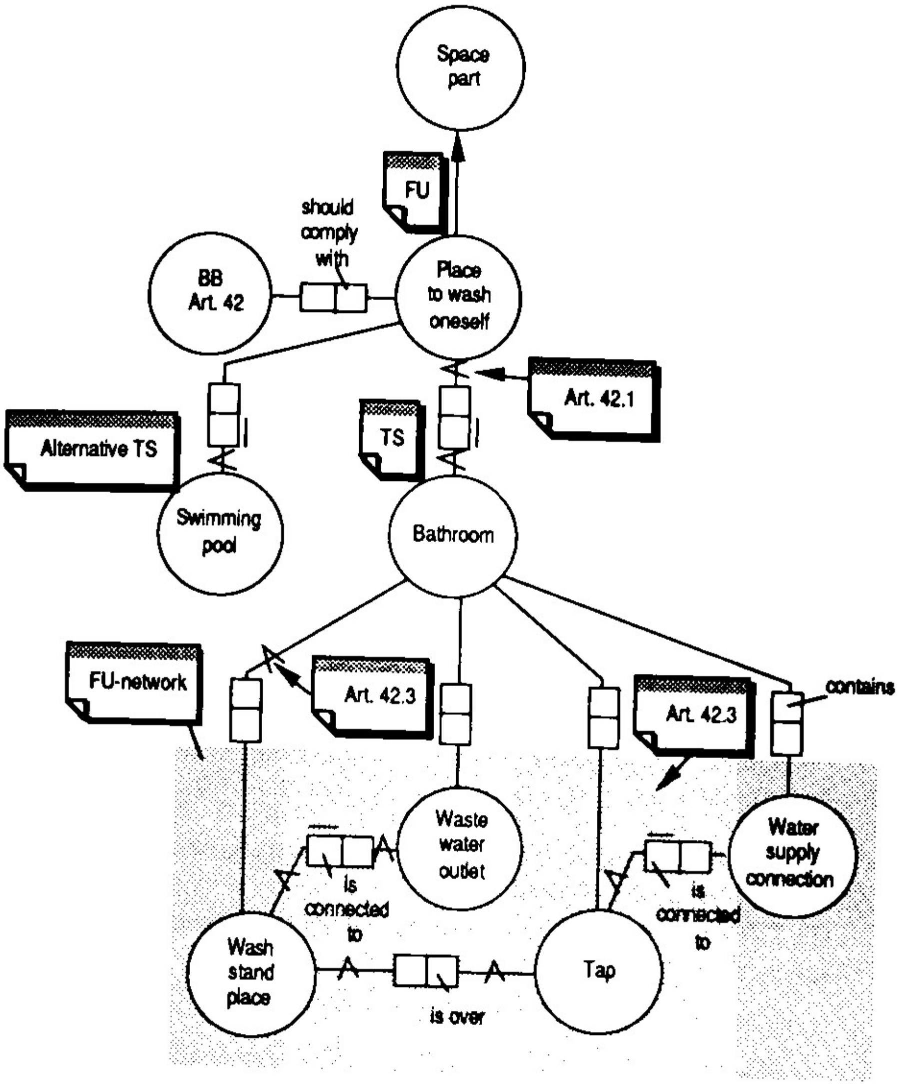

Figure 3. Part of the House model with BB requirements included

ummary and conclusions

:eptual modelling techniques can be applied to the process of compliance checking required in uilding industry. Computer Aided Compliance Checking, allowing the industry to submit the led designs in some computer format, requires (1) a neutral format for product data exchange eing developed by STEP), (2) a mapping of the semantics used in the product model to the ntics of the standards and regulations and (3) the implementation of the requirements of the ards and regulations in an information model. As an example of how CACC can be realized, aper (1) presented a small part of a producttype model for family houses (the House model), iscussed the semantical mapping required and (3) illustrated the modelling of some of the rements as described in our national global building regulation, the "Bouwbesluit" (BB).

ork proceeded it became clear that the development of an international standard for product exchange in a multi-vendor environment is mandatory to the success of CACC. The development of ISO STEP should be supported. A second conclusion is that it is not to difficult to develop a product model of a specific product, but that it is much more difficult to develop a product type model which covers a range of products of the same type. Especially the incorporation of realistic parts of the standards, codes of practise, norms and regulations will take much time and effort.

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