ISO 13567 - THE PROPOSED INTERNATIONAL STANDARD FOR STRUCTURING LAYERS IN COMPUTER AIDED BUILDING DESIGN

Björk, Bo-Christer[1]; Löwnertz, Kurt[2] and Kiviniemi, Arto[3]

ABSTRACT: Layering is a widely used method for structuring data in CAD-models. During the last few years national standardisation organisations, professional association, user groups for particular CAD-systems, individual companies etc. have issued numerous standards and guidelines for the naming and structuring of layers in building design. Recently ISO has defined a draft international standard, ISO/DIS 13567, in order to increase interoperability betwen different CAD applications for building design.

The principles which have been followed in the design of the draft standard are first presented, after which the paper describes the semantical organisation of the standard proposal and its default syntax. Important mandatory information categories deal with the party responsible for the information, the type of building element shown, and whether a layer contains the direct graphical description of a building part or additional information needed in an output drawing etc. Non-mandatory information categories facilitate the structuring of information in rebuilding projects, use of layers for spatial grouping in large multi-storey projects, and storing multiple representations intended for different drawing scales in the same model etc.

Pilot testing of ISO 13567 is currently being carried out in a number of countries which have been involved in the definition of the standard. In the paper two implementations, which have been carried out independently in Sweden and Finland, are described. The paper concludes with a discussion of the possible benefits of the standard. Incremental development within the industry, is contrasted with the more idealistic scenario of building product models.

KEYWORDS: CAD-system, layering, standardisation

1. BACKGROUND

The use of CAD-techniques in building design has increased rapidly during the last 10 years and is today the standard technique for producing building documentation. As a consequence of this the need to transfer CAD-information between the different participants in a construction project in digital form, and not only as plotted paper drawings, has become of vital importance. In contrast to the layout and symbols of paper drawings, which in most countries is more or less standardised, the techniques for managing digital CAD-data are still in their infancy.

The transfer between CAD-systems of the graphics contained in output drawings alone, which to some extent can be handled using standards such as the DXF-format, is not enough. Increasingly CAD-systems are used not as digital drawing-boards, but for managing integrated 2-D (or at best 3D) models of a complete building. (Excellent guidelines for end users and application developers have for instance been produced in Denmark). As a consequence a prerequisite for efficient data transfer and sharing is that the total information in models must be structured and partitioned in standardised ways. In current CAD-practice quite elaborate layering schemes, often used in

[1] Royal Institute of Technology, Stockholm, Sweden
[2] FFNS Group, Stockholm, Sweden
[3] Studio Kivi, Helsinki, Finland

combination with the reference-file technique, provide the dominating technique used to achieve this end.

In layering systems each drawing primitive in a CAD-file is assigned to some layer. The user can then interactively decide which layers to show actively on the screen or to output on a plotter using separate plotfiles. Reference file techniques enhance layering with some properties, in particular related to data security and easier management. User groups for particular CAD systems, individual bigger projects, large companies etc. have defined their own layering standards. Since the end of the 1980's also national standards or guidelines had been developed in a number of countries. In some countries (i.e. Sweden) the market dominance of particular CAD applications for building design has provided de-facto standards. Although most of these standards seem to use quite similar basic principles for layer division, the implementations and syntax's vary a lot and make data exchange difficult. Many of these standards also suffer from technical deficiencies resulting from the ad-hoc fashion in which they were developed.

This is the background for the decision of ISO TC10/SC8 in 1992 to appoint a new working group ISO TC10/SC8/WG13 with the scope of defining an international standard for the use of layering in construction. The committee had its first meeting in Stockholm in October 1993 and a CD-draft for the standard was approved in September 1995.

2. PRINCIPLES FOR THE DESIGN OF THE STANDARD

One problem in analysing the different national layering standards and proposals, which were included as background material for the work of the committee, is the ad-hoc way in which these standards have evolved and are presented. Most of them are no doubt easy to understand for a human reader but the format is not ideal for the analysis of similarities or incompatibilities between the formats, which is a prerequisite for the definition of an international standard.

The organisation of the standard is based on a fundamental principle of database design - the clear ***separation of the logical organisation of information (conceptual level) from the way this information is coded in particular CAD layer naming implementations (internal level***). For a description of this principle see for instance. The primary focus has thus been on defining a clear organisation of information describing a building which fulfils the functional requirements of the information users. A default syntax using a fixed length format is, nevertheless, included in the standard. This was deemed necessary due to the fact that end users and vendors seem to expect one proposed syntax (most earlier standards have one). It should, however, be stressed that the semantic structure of the standard could be easily implemented in many different ways (for instance including reference files and their file naming or using variable length syntax's with delimiters). In such cases the necessary requirement for a syntax to be permissible is that it is possible to unambiguously translate layer names back to the default syntax and vice versa.

A second overriding principle is ***orthogonality - the fact that many ways of classifying information are independent of each other and can be applied in combinations***. In traditional classification systems this principle has often been called faceted classification (used for instance in the original SfB system). In order to achieve orthogonality information of different nature should be placed in different parts of the layer name. Among the benefits of this is that it is easy to split up the information in a CAD model according to different principles. This principle has often been violated in current layering schemes, for instance by using sequences of unused numbers in an existing building elements table for denoting information related to the graphical outlook of drawings.

A third principle is the ***reuse of existing national or international standards whenever appropriate***. This is motivated by purely pragmatic considerations. An international standard which would try to override existing national conventions for the naming of floors in a building or elemental classification codes would cause a lot of resistance and would also result in a data structure which is incompatible with important downstream uses of CAD data, for instance in cost estimation packages which often are based on national classification tables. The negative consequence of this is that different aplications of the international standard are partially incompatible. But by a strict use of the orthogonality principle it should be possible to contain these incompatibilities as much as possible and to solve them by conversion tables for individual fields in the layer name.

The fourth principle which has been used is the use ***of well defined subsets of the overall potential space of layer names.*** This principle is implemented by making some of the overall information categories optional as well as by allowing the end user the choice of which of the mandatory specific layer codes (defined for some cases) he actually uses. The actual structure of the codes is also such that a sort of ***generalisation - specialisation principle*** is followed. For instance in the case of codes for the information category presentation, the end user can choose between a cruder split of information or a more granulated. It is always possible to translate information from the more detailed level to a more general level. For the case of the building element category the codes of the national building element classifications in most countries are constructed in such a way as to allow the implementation of generalisation - specialisation.

3. SYNTAX OF THE STANDARD

The currently most common type of layer naming offers an almost unlimited number of possible layers by using characters strings of fixed length. In some systems there is a limitation to 8 characters, but some offers longer names. Usually specific fields within the layer name are reserved for specific information types. The benefits of this are that it facilitates direct human interpretation. Additionally the length of each field is usually fixed so that no space needs to be used for delimiters. Some simple search strategies for groups of layers (i.e. wildcarding) are also easy to implement. Alphanumeric lists with free order could also easily be implemented. The benefit of this is that in a particular implementation space would need to be allocated only for those information categories which are actually used.

The choice of the recommended default syntax for the ISO standard was dictated by pragmatic reasons. There was strong pressure for fixed-order fields since most existing standards are implemented this way. Additionally there was some pressure to limit the length of the mandatory fields to eight characters since such a restriction exists in some CAD-systems. In the end this restriction had to be relaxed due to pressure for lengthening the element code to five characters. Figure 1. shows an example of permissible layer names coded using the default syntax.

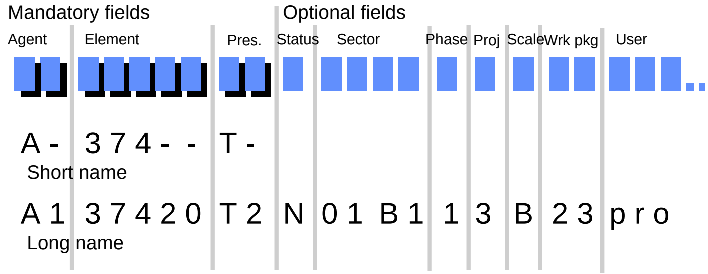

Figure 1. Layer name syntax with examples using mandatory fields only or all fields.

4. STRUCTURE OF THE STANDARD

In the following the different information categories are presented.

The **Agent responsible** tells which party (of the participants in a construction project) is responsible for the information. Since there is a multitude of possible classifications, depending on the type and organisation of the project at hand, no classification is included in the ISO proposal. In stead such classifications can be futher specified in national standard based on ISO13567 or project specific agreements.

The **building element** tells which part of the building is depicted. Classification tables for the functional parts of a building have been defined in many countries and are used to structure building specifications, bills of quantities, library information etc. In many existing layering conventions such classification tables have formed the backbone of the layering schemes. A serious problem is, however, that no international classification has emerged. For this reason the ISO-standard refrains from defining such a standard and allows any national or project specific element breakdown, provided that it is well documented. From a CAD-viewpoint a serious deficiency in many existing element tables is that they lack a category for pure space. If this is the case the recommendation is to add such a category.

The **presentation** code deals with what type of information a graphical primiteve or symbol contains. The information contained in a large integrated CAD-model can be broken down into two fundamental categories; information which is directly related to the model in world co-ordinates of the building, and information which is added to different output drawings in order to enhance readability. The first category includes the direct representation of the geometry of building parts (i.e. outlines of the sides of a wall) or symbols that in an abstract way represent such parts (i.e. a light switch). The second include drawing borders and headers, schedules etc.
For this information category the ISO standard contains a mandatory classification. This classification is, however, open-ended in the sense that it is possible for the user of the standard to create further subclassifications based on the different pre-existing categories. The second character of the presentation code, which isn't specified in the ISO standard, can be used for this purpose.

A study of existing layering schemes revealed that some of these contain features for dealing with demolition work, but often on a cruder level than for new construction. Whereas a full elemental breakdown can be applied to building elements to be constructed, sometimes only one code may have been reserved for any kind of demolition work. In the ISO standard the idea of classifying information according to whether a building part is to be demolished or built has been retained, but it has been treated as a separate facet called **status**. This results in a much more powerful mechanism which allows the modelling of the situation before and after rebuilding of existing facilities in the same model. It is for instance possibly at a glance to view all partition walls which are to be demolished, or all new walls to build.

Since layers are used to structure full building models in 2-D the layering facility is often used to split the information according to which storey in the building it pertains to. For some purposes there may also be a need to separate information depending on which part of a building it is related to. This type of split-up of the CAD-model is dealt with in the **sector** part of the layer name. Since the standards for coding storeys may vary slightly from one country to the other (which is the “first” floor?) no mandatory classification is proposed.

Sometimes it may be useful to use the layering facility to split up information according to the **phases** of a project, for example in project management. Such a classification is by necessity, project specific.

In 2-D CAD the CAD-model is used to store one or several **projections** of a building, rather than full 3-D model. The three main projections (plan, section and elevation) can be split into independent models, but for dimensional co-ordination purposes it can also be useful to store them in the same model. In such a case it is useful to be able to use layering for splitting up the model into these categories.

A common misapprehension among lay people is that the information contained in say a 1:50 or 1:100 drawing can be obtained simply by blowing up a 1:200 drawing. For some information categories this may be true, but in many cases the geometrical or symbolic abstractions used to represent the same building elements look quite different in different scales (figure 1). These different representations of the same parts share some properties, such as location points. It is useful if all of these representations intended for different scales can be included in the same model, rather than having non-integrated separate models for drawings at different scales. This can be acheived using the **scale** facet of the layer name. This information category could be very useful for instance for the manufacturers of building components, who may wish to build up libraries of standard CAD-details.

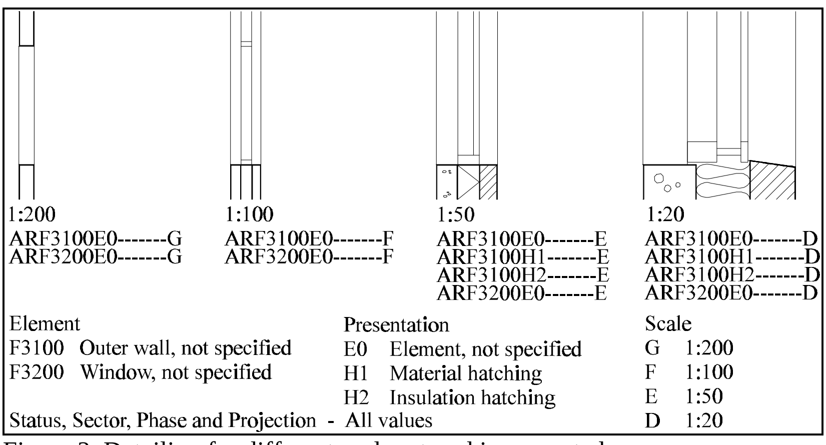

Figure 2. Detailing for different scales stored in separate layers

In addition to the subdivision of building parts according to their function it may be useful to have a subdivision according to the type of activities needed to produce the parts (**work package**). The last facet, **user defined** has been included to cater to any need the standard's writers didn't anticipate or didn't consider important enough to include as a specified category.

Of the above categories only the first three (agent responsible, element and presentation) are mandatory. All other categories are optional and the decision to use or not use a category can be done at the project level.

Within the standard there is a clear priority order for how particular codes (and thus also the underlying semantic categories) should be defined.

- A particular code is defined already in the ISO standard
- The codes are determined in some national standard
- The codes are agreed to on a project basis

5. PILOT IMPLEMENTATIONS

In the following pilot implementations in two countries, Sweden and Finland, are described. It should be mentioned that in both countries the organisations in charge of building standardisation are in the middle of a process of defining national implementation of ISO 13567. In these more specific codes for certain information elements, such as building elements, will be defined.

5.1 Testing in Sweden

FFNS Gruppen AB is a large consulting company comprising building and interior architecture, structural engineering, planning and landscape architecture, as well as project management. The company has about 500 employees on 24 locations in Sweden and 4 locations abroad. As part of a company-wide strategy for model-oriented CAD, an internal layering standard based on ISO 13567 has been defined and tested with real data. The layering application is focused on building architecture and structural engineering in the first phase.

The project was carried out by a group of experienced CAD users and developers, representing the different design professions. Present needs to structure CAD information, both for design and construction as well as for facilties management, were analysed. The layer structure of current application software was also analysed and compared to the needs that had been identified. The result of the analysis was to use the three mandatory fields of the ISO standard as well as the fourth optional field, Status. A uniform, 10-character layer name is thus used in the FFNS application.

The *Responsible Agent* field uses codes for the first character according to national standards for abbrevation of technical consultants etc. The second character is used to separate information for separate assignments of the same technical consultant, assignments to the building owner and tenants respectively. This is a somewhat irregular application of the standard, but this concept is not supported by any of the defined fields of the layer name.

Codes for *Elements* use national classification tables (BSAB system, table P2). This is a hierarchic system based on the function of elements, like load-bearing, room-dividing or climate-protecting. As a consequence walls, doors, windows etc. have different codes depending on their "main" function. Often, this is not suitable for the presentation of drawings. Therefore, when applying the codes, a code high up in the hierachy has often to be used, and complemented by additional coding for "secondary" function. As a rule, the three first characters are original BSAB code, while the following two are used for additional subdivision. Codes for spaces, which are not supported by the national classification, have been added. Space information has also been classified according to function; rooms, apartments, fire protection zoning.

The ISO standard contains the prescribed codes for the first character of the *Presentation* field. An additional presentation subdivision, which uses the second character, has been added for several categories, the most important being different kinds of text (see table below), hatching and information belonging to the drawing sheet.

Code	Content	Remark
T-	Text, general	Text not subdivided for presentation purposes
T1	Name	Classifier (eg. room name)
T2	Number	Identifier (eg. room number, type code)
T3	Quantity	Amount, area, volume

Figure 3. Presentation codes for text in model space

The *Status* field uses the reserved codes of the standard to denote the status of building elements, mainly to produce demolition drawings.

In the resulting applications (based on AutoCAD and the Swedish AEC application Point) the structuring of information in layers has been combined with a model oriented approach to 2D CAD. Documents are produced using file references with a model space/paper space system. All information is stored on file servers in a company wide network. Files are named and placed according to a company standard file system.

A simple user interface, based on prototypes developed earlier by members of the ISO working group, was designed for the creation and visibility control of layers. From lists of allowed codes for each separate field, the layer name or group of layers is composed. If this specification results in a layer that is not present in the CAD file, a new layer can be automatically created. In the design of the user interface, the educational aspect was considered very important. Therefore, the number of functions is quite limited. No courses to educate the CAD users should be necessary. This approach seems to have fulfilled its purpose - the new systems were accepted very rapidly and there were few question about the use. In future versions, more elaborate management of the structure can be introduced. In addition to the Layer Manager, automatic assignment of layers has been embedded in all functions of the AEC application program, and conversion programs from the previous layering structure and back are available to the user.

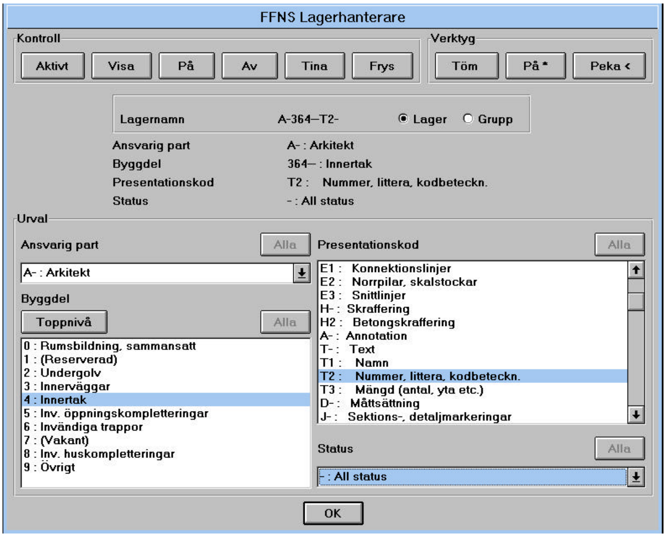

Figure 4. FFNS Layer Manager dialogue box

The proposed layer structure was tested using data from a real project. The plans for a hospital wing was chosen as sufficiently complex for the purpose. The layering structure of the CAD-files was converted from the old system to the new one. Conversion was done by using macros for mapping the layer structures to each other, and then manually refining the layering using the new structure.

Very few problems occured in the mapping process, much due to the way the layer tables had been designed, taking into consideration the layer structure of the previously used application as well as the desired structure. The conversion from the old structure, however, means that further subdivision has to be done manually in order to arrive at the full functionality of the new structure. This additional subdivision is of course lost in the case of a conversion back to the old structure.

The tools for handling separate layers as well as logical groups of layers have proven useful to identify and correct the placing of elements on different layers. Previously this has often been a problem in all those cases where application software cannot automatically dedicate information to the appropriate layer.

The number of layers used in a project are not by far as many as the standard allows. Standard layer lists, that are loaded with every new CAD file, contain about one hundred layers. These are the layers found to be currently used in order to control visibility on drawings and on screen.

The feedback from the first months of use in FFNS indicate that:

- Layering as a method is well suited for the logical structuring of building information and ready for wide-spread introduction.
- The application based on the ISO standard is readily accepted by users - clarity in structure is appreciated (as opposed to most systems developed by vendors).
- The layering method can be introduced with self-education supported by tools that help the users to understand the structure

- Clients are interested. As better use of information structuring depends on better customer demands, this interest may be the platform for better integration in the construction and facility management process.
- The ISO standard is easy to adapt to national and company specific conventions. Structuring problems were mainly found in applying national classification systems not suited for (and originally not intended for) CAD applications.
- There are lots of personal views on Presentation. This concept is not homogenous, and the different aspects that are included can not easily be combined into single codes.
- An application interface is needed to handle the layer name. This is no major problem, since the interface also gives new possibilities.

5.2 Testing in Finland

Studio Kivi is a small architectural design practice in Helsinki. CAD systems have been used by the studio for a number of years and experts from the firm have participated in national R&D projects as well as in the teaching of CAD-techiques to students of architecture. Studio Kivi has been testing a layering system based on ISO 13567 in several building projects since September 1995.

In Finland most of the CAD-layering implementations already in use have in some way utilised the national building element classification systems (House 90). In the adaption of the ISO standard the three first characters (one letter and two numbers) in the element field are consequently directly based on the Finnish standard element code. All five characters allowed for are not always necessary, but can in some cases be utilised. The recommendation is to use numbers as the two last characters, where 00 corresponds to the cases, where the element is not specified.

In the presentation category the possible values of the first character are already specified in the international standard. The second character is however open to national or company-specific adaptions. It can for instance be used for different levels of identification needed in different phases and plots of a project (0 = ID-number, 1 = type etc.). This field could be used also for different languages in multi-lingual projects (quite common for Finnish design companies) by using letters (F = Finnish, R = Russian, S = Swedish etc.). In the testing material suitable projects were not included, so it was not possible to test this feature.

The actual full layer codes resulting from the ISO standard are not human readable. For this reason an application with a user interface which provides full explanations to the layer contents is absolutely essential (see the chapter “User interface”). An application was developed to fulfill this demands. The prototypes were developed using AutoCAD version 12 for DOS and version 13 for both DOS and Windows platforms. The basic idea is to have a project database or even a simple ASCII file where each layer name, the color and the description of the use is recorded. When a drawing file is opened the data is read in and each actual layer name and the description is combined. In every possible place on the screen the user sees the description of the layer’s usage instead of the code name. AutoCAD’s common layer dialog is enhanced with a new dialog.

The user can select the layers by their properties - color, element, presentation, status and description - or even a combination of those . When the user wants to create a new layer to the drawing, he can do it using the “Make” button, which gives a list of all pre-defined layers which are not yet in use in the drawing at hand . If a suitable layer does not exist, the next level “Create a new layer” gives the user the possibility to create a new layer alltogether and also to include it in the project database. All possible element, presentation and status codes and colors are available in the list boxes and the user can write any description to the new layer. All parts are checked before a new layer is accepted.

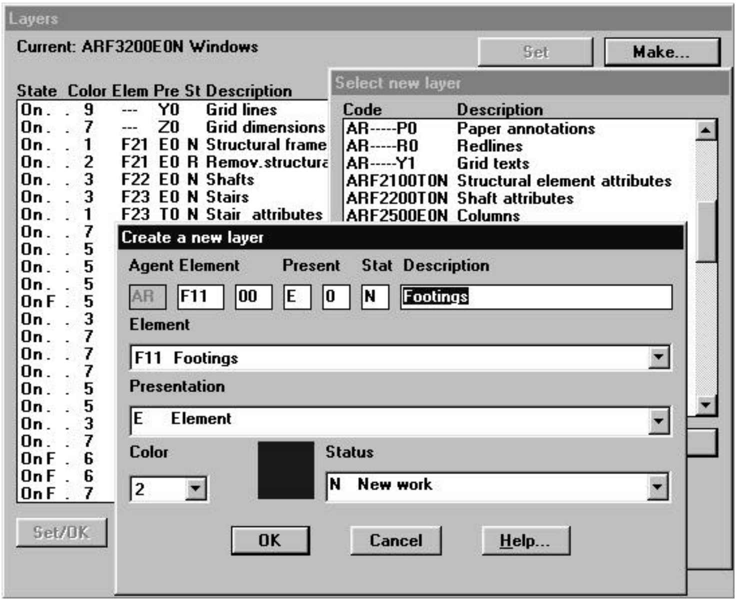

Figure 5. Dialogue for creating new layer

The prototype implementations have been tested in a number of projects. In the case of the ICL Finnish Headquarters in Helsinki (140.000 m³), the design work had been half finished using an old layering system. The CAD-files where, however, converted to the new standard for facility management purposes. One existing and very big building complex (University Hospital in Oulu, 600.000 m³) was measured and drawn as a CAD-model for facility management purposes. Part of this data was structured using the ISO-based standard. The other test projects were renovations of different sizes and of different building types: an office building, a hotel, two military buildings and a warehouse. In some of these projects CAD-files describing the existing situation, in which the original layering system was not in any standard format, could be used as input information. In other projects the CAD-files had to be drawn manually from paper copies.

Alltogether seven projects with total of 40 drawings were included in the testing. The total area covered in these drawings is about 125.000 m². In each project the actual layer structure was different. There was no correlation between the number of layers used and the size of the project. The number of layers was, however, clearly affected by the type of the drawing and the design stage, which seems quite logical. The actual number of layers in use naturally depends on the user and the application at hand. The number of defined layers in each project was 100-140, but only half or even a quarter of them were really used in the individual drawings. Almost half of the drawings were detailed plan drawings, where the average number of layers was 50. At the sketch stage the average number of used layers in plan drawings was 22, but only 5-8 of these were actually needed by the user at this design stage. If the drawings were made for facility management purposes, the average number of used layers was 29. All in all it seems that the users are willing and able to use a minimised set of layers for their purposes, which also is the sensible way to work.

The new layering system was found to offer significant improvements compared to the old Finnish systems, especially in renovation projects (figure 1). Most current applications are made only for design of new buildings. The idea of a separate status field is essential for renovations.

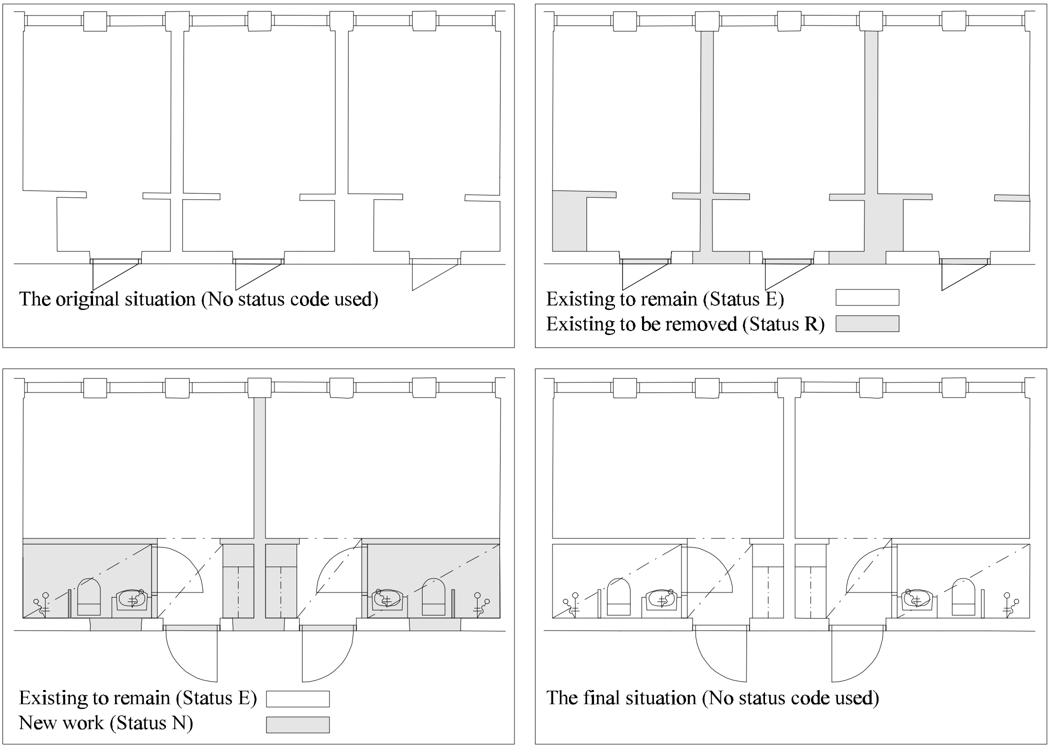

Figure 6: An example of how the status field can be used as a discriminator to produce tailor-made drawings facilitating the design and management of rebuilding.

Some other conclusions of the testing by Studio Kivi were:

- The creation of new layers must be controlled so that the structure and syntax is checked for correctness. If the users can invent new layer names without any checking system, the system may not work because of human errors.
- The documentation of the layer structure in use must be made in every project and archived with the other documents. The documentation must be made both human and program readable and it must be updated automatically, when a user makes new layers.
- The number of pre-defined layers should be much greater than the number of layers actually used in each CAD-file or model. This is important in order to prevent end-users from inventing their own layers if such codes are anticipated in the standard itself.
- The experiences from the projects indicate that apart from the status field the other optional information categories of the ISO standard are not usually needed. Consequently they were not tested in the test projects described above.
- The structure and codes of the presentation facet seem to enhance the control of what is shown on the screen from a CAD-model (which is the essence of layering)
- The translation from old layering systems in use was very ease to arrange, because of the higher accuracy made possible by ISO-13567.

6. CONCLUSIONS

We would claim that “Best practice” use of commercial CAD-systems is much more model-oriented than many researchers, who primarily are interested in product modelling, seem to think. Hopefully this new standard would contribute to make such best practice common practice. Compared to the majority of the large number of layer standards now in use the proposed international standard would seem the following benefits:

- One international standard in stead of a multitude of national, user-group and company-specific standards.
- Strict adherence to certain guiding principles (i.e. orthogonality).
- A comprehensive coverage of foreseeable user needs (union rather than least common denominator)
- A flexible structure allowing its implementation at many different levels of detail
- A structure which makes it easy to convert existing layered CAD-data into an ISO-compatible format (“backwards compatibility”)
- A structure suitable for the later reuse of data in product modelling software (“forwards compatibilty”).

The last point is important. It is hoped that the standard would facilitate the use of layered CAD-data as input information for the more advanced product model based systems of the future. The possibilities for integration with document management systems are also important since many of the information categories dealt with also occur in the reference information that document management systems use for document search and retrieval.

7. REFERENCES

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