PLAUSIBILITY IN ARCHITECTURAL DESIGN
– SOFTWARE SUPPORT FOR THE ARCHITECT-ORIENTED DESIGN OF COLOUR SCHEMES FOR INTERIORS AND BUILDINGS

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Colourful is my favourite colour. (Walter Gropius, 1921)

1 Introduction

The approach discussed here is part of research into an overall concept for digital instruments which support the entire planning process and help in enabling planning decisions to be based upon clear reasoning and plausible arguments.

Such specialist systems must take into account currently available technology, such as networked working patterns, object-orientation, building and product models as well as the working method of the planner.

The paper describes a plausibility instrument for the formulation of colour scheme proposals for building interiors and elevations. With the help of intuitively usable light simulations, colour, material and spatial concepts can be assessed realistically.

The software prototype “Coloured Architecture” is conceived as a professional extension to conventional design tools for the modelling of buildings. As such it can be used by the architect in the earliest design phases of the planning process as well as for colour implementation on location.

2 Colour as an essential design decision

Architecture is “designed” space. The colour and characteristics of a space’s surfaces play a significant role in the “design” of architectonic space.

Surface characteristics apply to both interior as well as exterior space, and are dependent upon the environment as well as mobile elements, fittings and extensions. The exploration of and determination of colour values and their application to different built surfaces is a complex and creative process which is part of the architectural design process. The selection, determination and application of colour is an aspect of almost all design phases and occurs in conjunction with other design decisions (form, function, construction) and is influenced by a number of factors (light, material, surface temperature, subjective perception etc.)

These activities are part of an architect’s remit, and arise repeatedly during the planning process: colour variants are developed in all phases of project development and design and must be amended to reflect design changes and redesigns. Not least, they should accurately reflect the actual application of colour on site (correct colour tone and saturation). A good feeling for colour and its impact is very important (van Doesburg, T., 1928 / Judd, D.; 1994).

A good knowledge of colour systems and their effects within particular spatial situations, in conjunction with particular materials and surface qualities and the influence of light on colour and atmosphere are only some aspects necessary for professional design of colour schemes. The tools and working methods are in principle relatively simple and have not changed significantly over the years: interior rooms or exterior elevations, perspectives or isometric representations are drawn to scale and coloured as a means of exploring (for the designer) and communicating (for other participants) colour schemes. Colour scheme variants, detailed vignettes, colour samples and colour collages form the basis for planning decisions. Very often such decisions are often made independent of other design aspects such as spatial organisation, environment, the atmosphere of a space, its use, material or construction.

3 Colour in architectural design and its implementation in current CAAD systems

Modern-day design and planning in architecture should make exclusive use of CAAD systems. Architect-oriented colour scheme design is rarely or only poorly supported in currently available commercial CAAD systems.

Depending upon the manufacturer, different CAD systems support different colour palettes such as the RAL-system or the Pantone© colour system. (*see Fig. 1: Example of RAL colour systems in commercial CAD systems*). These can be attributed to 2D or 3D objects as colour values in CAD systems. A variety of commercial modules or plug-ins are also available which integrate different colour palettes into various software tools (e.g. the colour atlas from *www.dtpstudio.de*). This add-on approach does not directly support the needs of the planner in an architectural planning environment. A comprehensive architect-oriented system is necessary which supports such design decisions from start to finish by providing colour experimentation, management and representational functions.

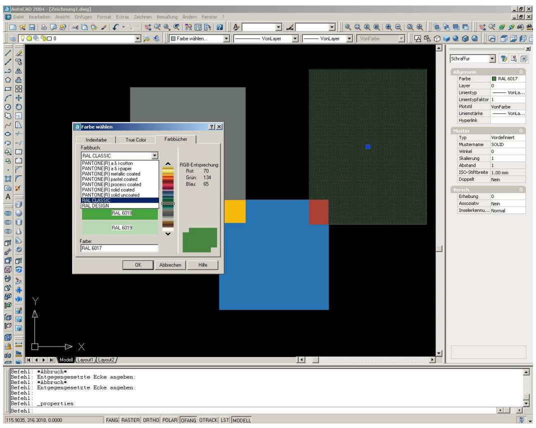


Fig 1a: An example of RAL colour palettes in commercial CAD software: here AutoCAD, RAL Classic colour palette, ©AutoDesk

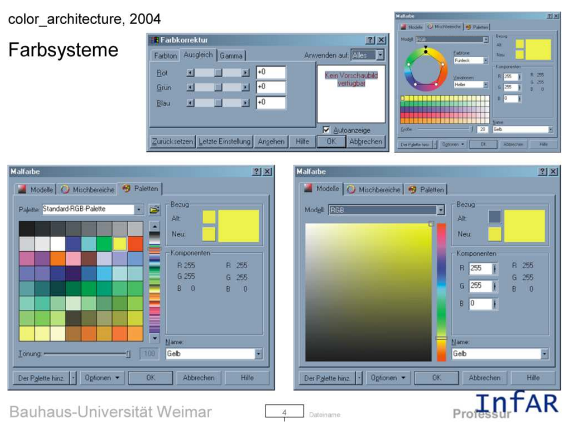


Fig 1b: different colour palettes in image manipulation software: here Corel Photopaint ©

It is not important whether 2D drawings or 3D models are developed; the previously discussed colour considerations and final implementation are independent of this. The graphic product of CAAD supported working methods, “the drawing” (digital or otherwise), is used as a basis which can be ‘filled’ with colour appropriately. Current CAAD systems support the design of spatial geometry and can produce representations of this in the form of images, element catalogues or bills of quantities. Functions which support the plausibility of these representations are not available. The integration of colour scheme design in the complex process of design is not supported whether with regard to the informational or structural CAAD models.

4 Colour experimentation using planning-oriented CAAD-based tools

CAAD systems offer the potential of providing the architect with comprehensive information which can help in the reasoned and informed development of planning solutions, not just the formal design aspects.

The architect very often develops basic design decisions from formal-aesthetic considerations which are often very subjective in nature.
The plausibility of functional or constructional aspects is often neglected in the earliest phases of design development. These are often derived and calculated at a later date based upon design decisions made previously. The results do not always support the design decisions and can necessitate changes to the design, which in turn lead to the process being repeated: design investigation, calculative realisation, assessment, decision.
Functions which support design plausibility are intended to show the designer the effect and consequences of design solutions as and when they are made. Design factors are highly complex and inter-dependant. The formulation of space should be made manageable. An example is the effect of room-depth on the natural light levels within a room, the illumination-requirements for work spaces, the mechanical ventilation requirement and the direction and span of ceiling elements. Many further prototypes have been developed by the authors and colleagues in recent years: the optimisation of plot use as a result of building distance and plot density parameters, the determination of the psychologically pleasant colour of room environments, the artificial lighting of indoor spaces, the derivation of the structurally optimal form of gridshell structures based upon design parameters etc..
These developments have spawned a number of software modules which can be used parallel to CAAD systems as required to provide a concrete basis for informed design decisions.

5 Coloured Architecture [*C_A*] – Digital colour development in design and planning

The planning concept supports all typical and necessary investigations, representation and realisation requirements for colour schemes in architecture.

The experimental system C_A [*Coloured Architecture*] is oriented towards the requirements of the planning process and communication of the results, and has demonstrated in experimental implementation that such a CAAD-based approach can be used for colour-scheme design and decision making. The use of the system enables the following:

- The exploratory and intuitive application of colour schemes for particular building surfaces.
- support for design-process dependent colour scheming, i.e. from a variety of ‘unsure’ design proposals in the first phases to the exact specification and colour catalogue for use on site.
- Support for particular colour combinations, i.e. project specific or ‘favourite’ colour palettes or colour combinations.
- Consideration of the architectonic play of material and light
- Incorporation of technical colour systems (RAL, DIN, CIE Lab, Munsell, CMYK, RGB, LAB, HSB etc.) as well as specific product-based colour palettes.
- Avoidance of redundancy as a result of working in different geometric models and drawn representations. Colours are applied to building elements and objects in the CAAD model rather than projective representations thereof.

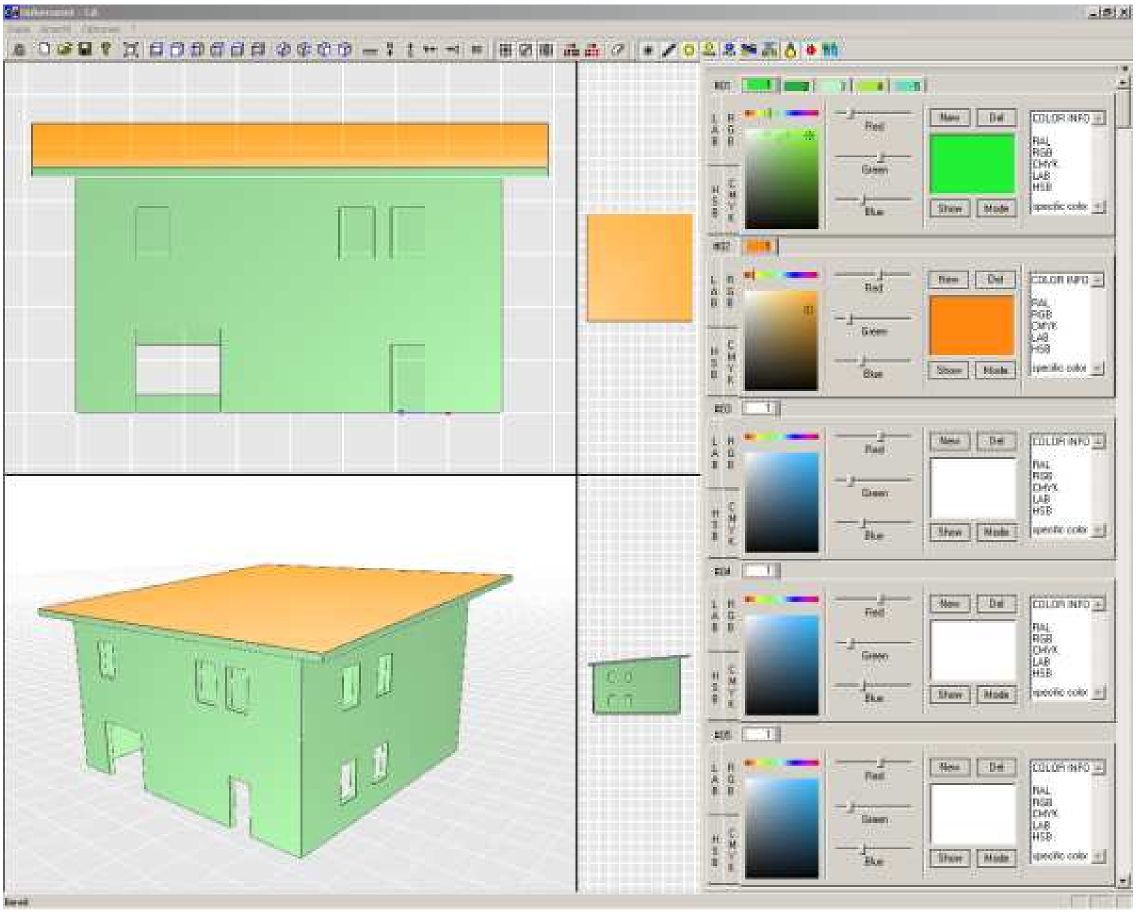
- The specification of colours on site (which walls and elements are to be painted with which colour) e.g. the transfer of CAAD-based information to exact specifications for the building site (colour charts for rooms, sample cards),
- Demonstration of the value of 3D CAAD systems in the support of design plausibility in the design process.

The concept of the experimental system C_A is oriented towards the needs of the planner and consists of three primary components:

A Colour attribution
B Colour evaluation
C Colour implementation

5.1 Colour attribution

Colours can be applied interactively to all spaces or elements defined in a CAAD model including their surfaces or parts thereof. Each surface of an elevation, each wall surface, each window frame or glazing bar that has been defined in a CAAD model is linked to a digital colour object with the respective colour information (saturation, lightness etc.) Spaces and elements can be grouped and combined to simplify and coordinate the application of colour schemes. A building element can be separated via different sectional levels into sub-areas and coloured differently as required. This can take place through the use of “working views” in CAAD systems and/or using the elevations, indoor room elevations, panoramas etc. generated from the CAAD model. (*see Fig. 2: Coloured Architecture: Part of the colour choice dialogue box for applying colour in the planning process.*)



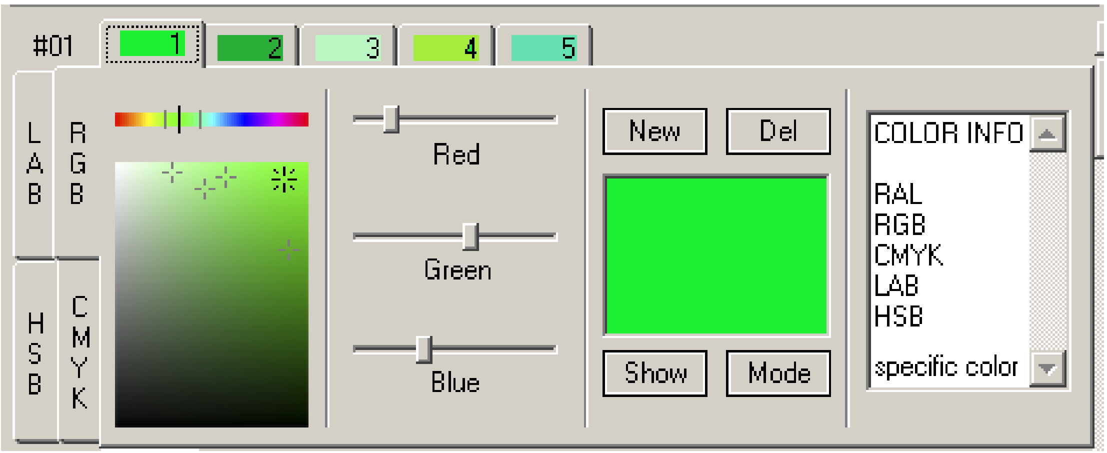


Fig. 2: Coloured Architecture: Part of the colour choice dialogue box for applying colour in the planning process.

In addition to exact fixed values, value areas can also be defined (tonal value, lightness areas etc.). Each sub-stage can be defined as a variant and combined. Through the grouping of colours and colour variants, particular colour situations (lightness regulation by same tonal value) can be assembled and archived.
Following the object-oriented approach of CAAD systems (Beucke, K., 1995), the colours can be directly applied to the CAAD model elements as room or element properties in the form of attributes. A variety of colour systems (RAL, DIN, CIE Lab, Munsell, CMYK, RGB, LAB, HSB etc.) or product palettes according to the manufacturer can be used and translated (as far as is technically possible). To ensure that the digital colour used (screen, plotter) corresponds to the actual colour, a variety of different adjustment, calibration and proofing functions are available (*see also Fig. 1a: Colour palettes in different systems: here Corel Photopaint©*).

A further concept takes account of the influence of light and material properties on surface colouring and the entire effect of colour in a building: Exact colour combinations, additive (light rays, monitor, RGB) and subtractive (CMYK, paint mixtures, printer), either through the specification or evaluation of "colorimetric coordinates' such as RGB-values and further properties in relation to both architect-oriented and technically verifiable colour definitions.

5.2 Colour evaluation

The evaluation of colour is largely dependent upon the so-called "subjective colour impression" and is based upon our psychological pattern of perception, our aesthetic response and individual character. In addition there are a number of conventions, traditions and restrictions with regard to the effect and interaction of colour in architecture. These aspects will most likely remain as valid as ever. The experimental system as discussed here should provide the necessary basis to transform these sensory-perceptive impressions into planned colour schemes (*see Fig. 3 Coloured Architecture: comparison of colour scheme variants using 2D-views of a CAAD building model*). The system supports the typical working method of architects and planners.

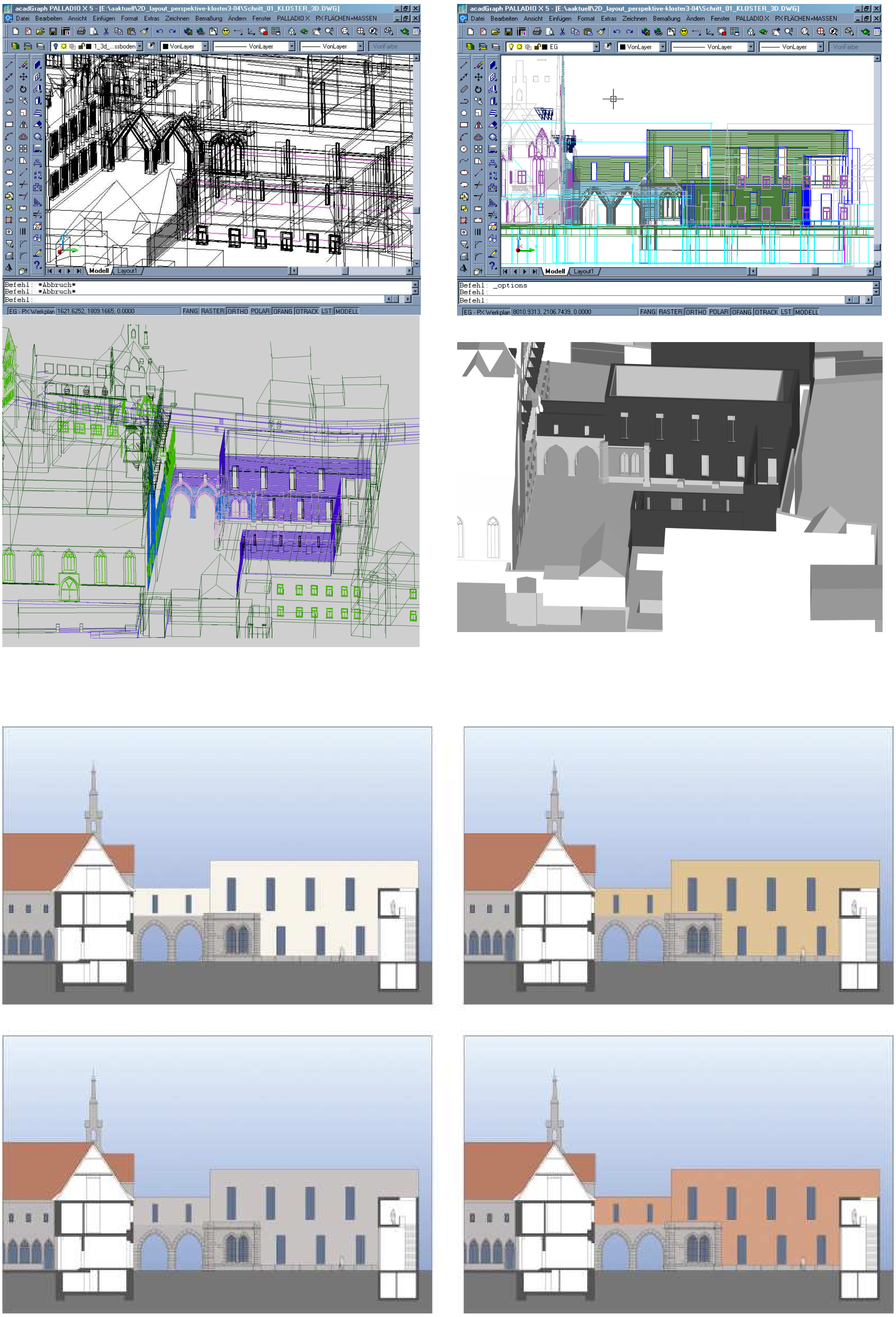


Fig. 3 Coloured Architecture: comparison of colour scheme variants using 2D-views of a CAAD building model (Augustiner-Kloster Erfurt, Competition, 2004 © nitschke-donath architekten)

5.3 Colour implementation

The comprehensive use of complex CAAD tools throughout the entire planning process also enables the results in digital form to be evaluated and edited on location before final specification.

A number of different systems for transferring working drawings and planning documents to the site have been developed in the last few years (*see System OnSiteEnterprise, 2004*). In the case of colour schemes it is equally useful as it is important to review the choice of colours on site. An evaluation of colour using swatches and samples (printed/plotted) requires correct colour management between all different presentation media i.e. monitor and digital output devices. The experimental prototype therefore includes classic colour calibration functions. In addition, a useful combination of classic colour scheme evaluation techniques is also part of the concept. Two typical techniques employed by architects are included:

- A room-by-room colour scheme output (indoor wall and floor/ceiling elevations) and
- The large-scale output of colour samples for trying out on site.

The derivation of colour-cards in the form of "space-colour-profiles" is a direct addition to the CAAD-generated room log and allows colour-schemes to be applied to wall and building-element surfaces room by room (*see Fig. 6 automatically generated wall and floor/ceiling elevations using colour profiling from CAAD model*). In addition selected portions of the model can be rendered and output as so-called colour samples at a scale from 1:100 to 1:1 (*see Fig. 6 Definition of selection for rendering as a large-scale sample printout for evaluation on site*).

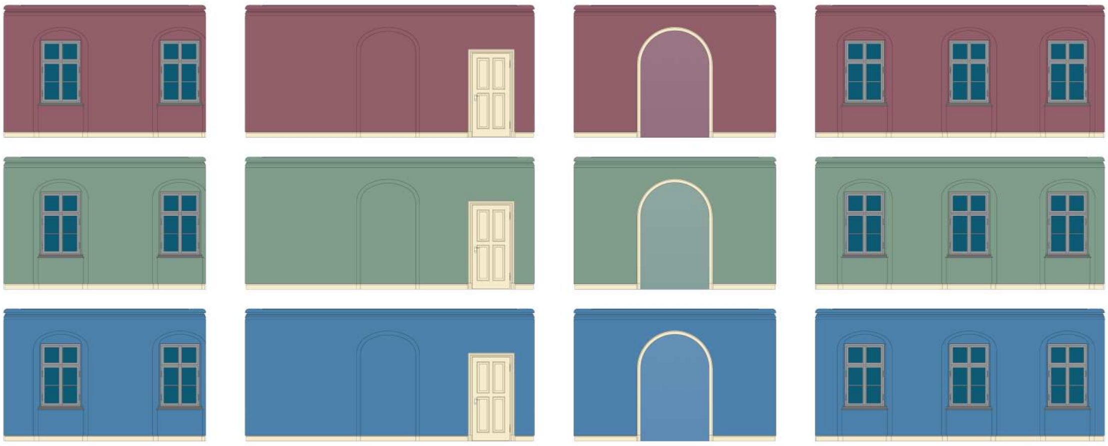
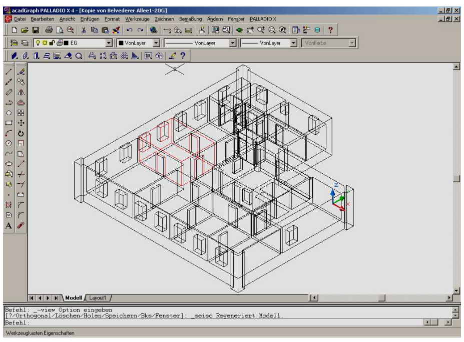
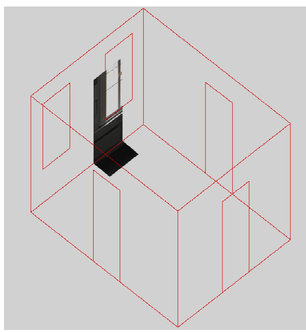


Fig 5: Coloured Architecture: automatically generated wall and floor/ceiling elevations using colour profiling from CAAD model (Wielandgut Osmanstedt, Ausführungsprojekt, 2004 © nitschke-donath weimar)

The room on site



Selection of room in 3D CAAD model



Selection of an area for a sample plot at 1:1 scale

see Fig. 6 Definition of selection for rendering as a large-scale sample printout for evaluation on site. Site: Belvederer Allee 1, Bauhaus Universität Weimar, 2004

To reduce errors or misunderstandings the sample printouts can be tried out on site. All samples include the details of colour properties so as to ensure the correct application of the colour envisaged (*see Fig. 7 Part of a room log including application of colour scheme and Fig. 8 Coloured Architecture: Interior wall and floor/ceiling elevations*).

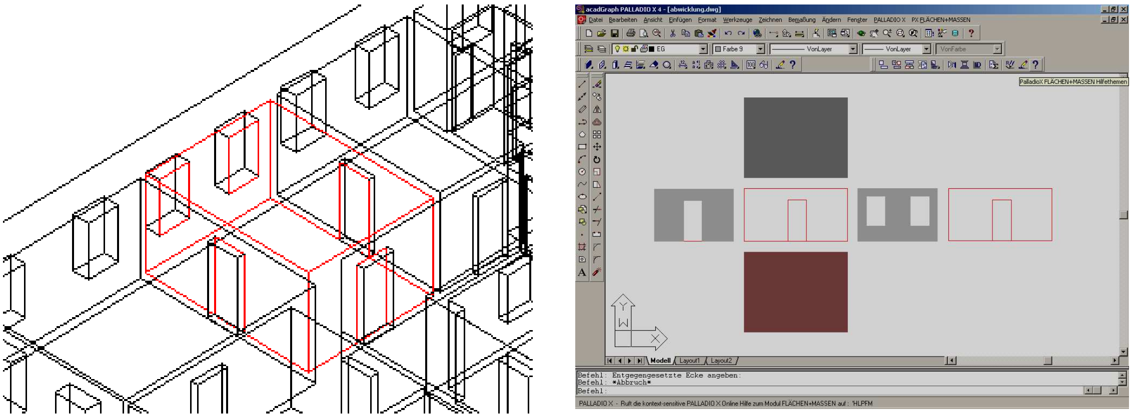


Fig. 7: Part of a room log including application of colour scheme

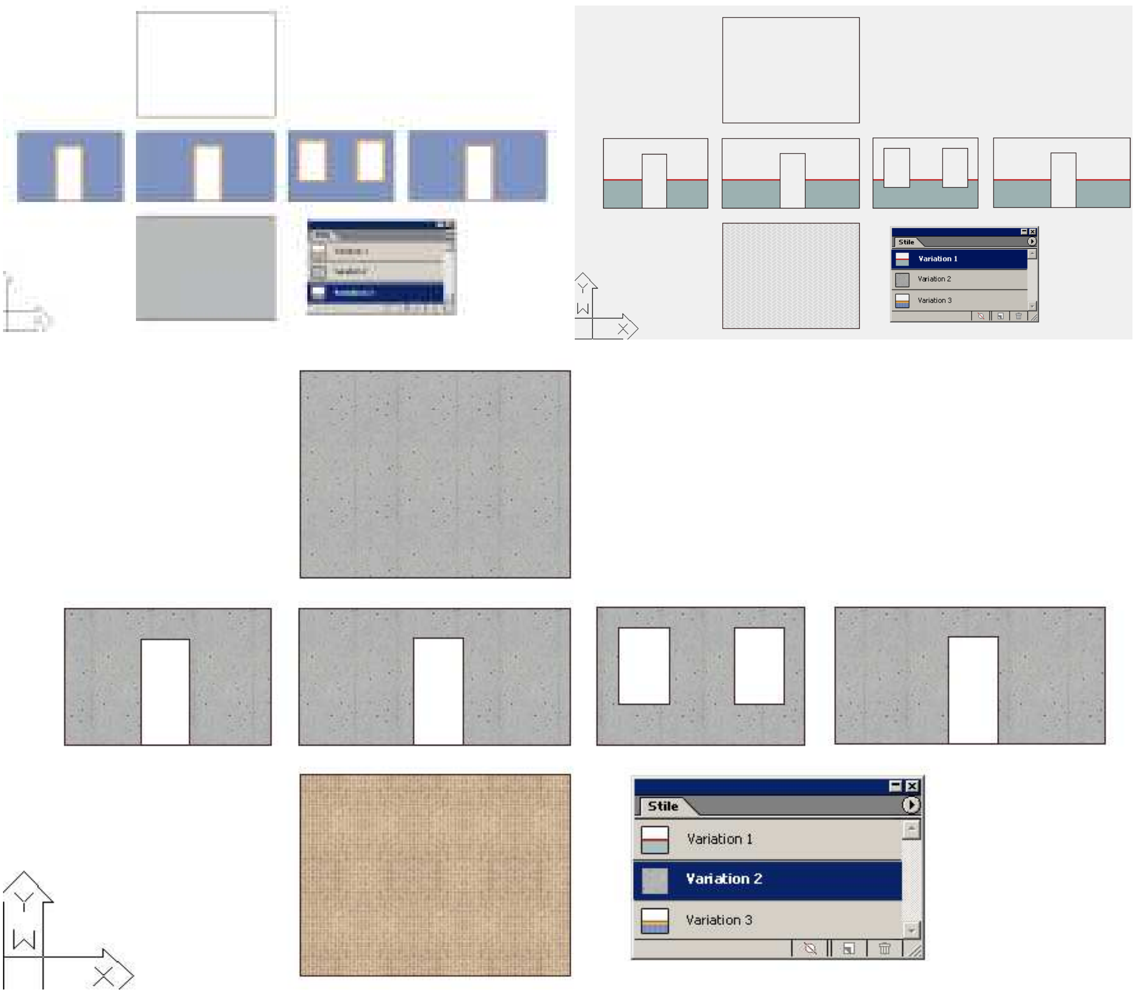


Fig. 8: Coloured Architecture: Interior wall and floor/ceiling elevations showing different colour scheme proposals based upon predefined space-colour-profiles. (Belvederer Allee 1, Bauhaus Universität Weimar, 2004)

6 More colour in architecture

The potential of such digital planning tools lies in the "added value" of CAAD: many more planning aspects can be digitally supported using CAAD systems than solely building geometry.

The concept discussed in this paper is an example of a task-oriented extension of current CAAD systems, maximising the use of CAAD-characteristic object-oriented structured building models. Colour scheme design decisions can be made and specified using the building model. The effect of light and material is as yet not implemented and is very important in order to correctly evaluate the effect of colours in rooms or outdoor environments. However, even this experimental development prototype already demonstrates the added value possible through the consequent use of CAAD: function, construction and not least design aspects have equal status and can be worked upon in direct relation with one another under the control of the architect.

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