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Integrated Plan Analysis (IPA) of Buildings

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ABSTRACT

At the Faculty of Architecture of Delft University of Technology we have developed a method for the integrated analysis of buildings. All faculty departments are contributing to this research project. The design and construction, use and demolition of buildings is analysed. Often elements of such research are undertaken in isolation, but in this project they will be linked. The objective is to produce a comprehensive analysis of a building, rather like a biography. A method called Integrated Plan Analysis (IPA) of buildings work will address: architecture, building technology, environment and sustainability, functions, costs, design and the construction process.

Keywords: Integrated, Architecture, Engineering, Environment, Functions, Costs, Process.

1. INTRODUCTION

The theme of the 2007 CIB congress is Construction for Development, focusing on the important role that construction plays in the development of nations, concentrating on the themes Sustainable Construction, Revaluing Construction and Integrated Design Solutions. The last theme is particularly relevant to the development of sustainable cities in the future. However, it requires that we first understand the city and its buildings.

At the Faculty of Architecture of Delft University of Technology we developed a method for the integrated analysis of buildings (IPA). All departments of the faculty are contributing to this research project: the departments of Architecture, Building Technology, Urbanism and Real Estate and Housing.

Buildings can be analysed in terms of the way they are created, survive and reach the end of their lives. Generally, relevant topics are studied in isolation. What we are doing is to link these topics to draw

conclusions on a more general level. This results in a more comprehensive outcome of the research. Our method covers: architecture, building technology, environment, sustainability, functions, costs, design and the construction process. Two case studies have been worked out yet.

2. PLAN ANALYSIS

Much information about architecture is contained in the buildings themselves: according to Kleijer (2005) designers cannot design without constant analysis: “my observations are based on the precept that the elements we use to analyse and assess architecture are in fact the same as the elements used by architects to create architectural designs”.

Plan analysis is a widely used teaching aid in design courses to help aspiring designers understand buildings, to learn about their layout and structural design, etc. What choices were made, who made them, and why? How does the design deal with utility of the building and the way it is experienced, with aesthetic considerations, the environment, costs, etc.? To what extent was the design determined by the personal preferences of the client and designer(s), and to what extent by the preferences of the users? Analysis is also essential when an existing building is to be modified. To understand an architectural design and appreciate its meaning we have to investigate the context in which it was created. This is because an architectural design is always related to an architectural and social culture. That includes the cultural history context in which the design was created, the zeitgeist, the state of the economy and applicable legislation and other regulations. Another important question is how the building has fared over time. What aspects were kept, and what were changed? Will the building be of any value in the future? If the analysis includes an assessment or evaluation then we have to ask: what is appreciated, what is not, and does this depend on the role of the actor (architectural critic, client, users, visitors, general public)?

By studying plans and buildings we can develop our own vision of architecture and learn to explain the reasons behind our own designs (in isolation and in the context of architectural culture), develop our own design method, and learn to truly appreciate buildings.

A new method could be developed out of different methods of building and plan analyses used at our university of technology by students and teachers. All used methods have been analysed and this resulted in a new overall, integrated, method: IPA. Used methods for instance are: Plan Documentation (Architecture), Architectonical Studies (Architecture), Building Analyses teached by Prof. Ir. Fons Verheijen and myself from 2001-2005 (Building Technology), Comparative floor plan analyses (Real Estate & Housing), GreenCalc+ method (Building Technology), Sustainable Development (Uranism) and my dissertation (2006) in which I developed the Analysing Building Construction method out of seven case studies. Also research has been done on other methods described in literature.

In the end of this paper some results are presented in figures of the case study; the building of the faculty of architecture TU Delft. The complete analyse is published in a book in 2007. Students will use the method during some exercises in the Bachelor Curriculum. See figures 240.2-9.

3. OTHER METHODS

Plan analysis is often focused on an architectural analysis. Images and descriptions of the building mass, cross-sections, floor plans and the use of colour and materials are used to analyse the situation, spatial structure, use of materials and the relationships between form, function and technology. This often results in impressive studies of specific aspects, but the process of creation, costs, influence of the local context and the experience of day-to-day users and visitors are often neglected. Thus, I advocate the use of integrated (i.e. comprehensive) plan analysis to address all these aspects. This would both recognise the complexity of the design assignment and show that designing amounts to aiming to combine many and diverse requirements, wishes and constraints, resulting in the building as it is built. See Figure 240.1.

Clark and Pause (2005) documented and analysed 104 buildings. Their book systematically described these with a double-page spread for each plan: the site plan, main building plan(s), sections and facades on the left, and on the right a reduction of the drawings to their essentials, using a standard template:

- plan structure (typological scheme);
- section in relation to the daylight entering the building;
- plan in relation to the section;
- internal traffic circulation patterns;
- geometry;
- additions and subdivisions;
- hierarchy;
- building mass;
- relationship between parts of the building and the whole;
- repetition and unique features;
- symmetry and balance in the composition;
- parti (nondimensional representation of a project).

The second half of their book addresses the analysis categories and establishes links between different and equivalent design solutions. These categories are particularly useful for the architectural analysis of buildings. The drawings in the book are thumbnails, hence the use of materials in the designs is not shown.

Ching's method (1996) is typified by a uniform style of pen and ink drawings which simplify reality into its essence. The book also presents architectural observations from different viewpoints. The comments essentially deconstruct the building, helping us to understand the formal

structure of the plan and the design approach which led to it. Key elements in Ching's analyses include mass, space and shape, horizontal and vertical elements, the organisation of space, circulation, configuration, composition, proportions (matter, structure), scale, layout and the principles of arrangement. Order is subdivided into physical, perceptual and conceptual order. According to Guney and De Jong (2005), Ching's analysis method can be described as: ” The architecture of space, structure and enclosure, experienced through movement in space-time, achieved by means of technology, accommodating a program, compatible with its context".

The work of Tzonis (1987) and his staff such as Koutamanis (1990) and Zarzar (2003) is characterised by formal representations. Building plans are reduced to their essence, in the form of abstract topological representations. The building to be analysed is reduced to its formal structure in terms of planes, lines and nodes. It is then investigated how the building works and how successful it is. In plan analysis, the order of the triplet Form-Operation-Performance can be reversed. A retrospective analysis of the performance of a design or building, and investigating how this performance was obtained through the operation and the formal design tools used for this, results in the order P-O-F.

Steadman (1983) similarly concentrated on morphological analyses. His approach to plan analysis could be described as "design by analogy". By drawing the design or building under study in the form of metric and topological representations Steadman aims to understand how the design was developed. Manipulating images (enlarging, reducing, stretching or compressing elements, etc.) and comparing design solutions with analogies (e.g. animal shapes and meanings) can lead to a new appreciation of the design.

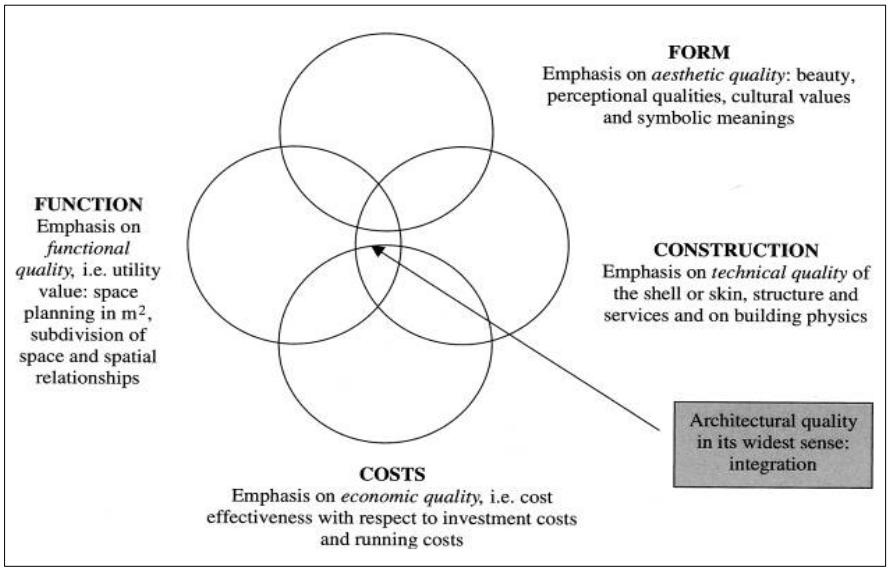

Figure 240.1 Architectural quality is related to integration (Van de Voordt 2000)

4. INTEGRATED PLAN ANALYSIS

The methodology largely depends on the objective of the analysis. The wider the scope and the greater the depth, the more sources will need to be consulted and the more measurements will have to be made. The following sources can be identified, from quick to apply with little depth through to more comprehensive and requiring more effort:

- Visit to the building, on site measurements (observations, use of measuring instruments.
- Drawings: plans, sections, facade drawings, structural drawings, detailed drawings, 2D or 3D, perspective, isometric or axonometric.
- Site plans at different scales (immediate surroundings, street, neighbourhood, district, town).
- Design sketches.
- Images (photographs, models, renderings).
- Documents such as vision documents, plan documents, specifications/schedule of requirements, minutes of construction meetings, notes on the plan by the designer and the budget.
- Literature, including earlier plan analyses and plan discussions.
- Interviews, for example with the client, designer, day-to-day users, visitors and the general public.
- Reference projects by the same or other designers.

4.1 Framework

The first part of the method (facts and context) includes an itemised list of the main project information, summary of the brief, and a description of the site and important aspects of the building.

The second part of the method includes the analyses. These provide descriptions of the building as a whole and specific elements of it, and an interpretation and assessment of the building's characteristics. This assessment can be based on various approaches and disciplines relevant to architecture professionals, users, visitors and the general public. In essence, this amounts to comparing the characteristics of the building and an assessment of its architectural quality, incorporation into the townscape, technical, structural and building physics aspects, utility and experience, economics and process.

This analysis is divided into six component analyses. The scope and depth of the analysis depends on the objective and the resources available. Each of the component analyses includes a number of primary and secondary aspects.

Finally, conclusions are drawn which gain an added dimension as the result of the integrated approach. To compare the results of the different components of one building that will lead to different conclusions. To define overall conclusions by comparing different buildings after they

have been analysed is not the goal and impossible after just two case studies.

4.2 Architectural analysis

We will consider the architectural and cultural history values, stylistic characteristics, symbolic meaning (semantics), emotional meaning and aesthetics. According to Nelissen (2001) the intention is to encourage people to take a good look at the architecture surrounding them. Rather than architecture as such, this relates to architecture in context - the context of the time and place where it was created, developed and operates.

There are many ways to analyse buildings. A building is only considered as an architectural object once it is completed. The assessment by architectural professionals often determines whether something is considered as good or bad architecture. Outsiders are often unfamiliar with the arguments used to come to that conclusion. Many assessments appear to be highly intuitive, based on personal preference, taste and fashion. There are many approaches to analysing architecture. It is important that the analysis focuses on aspects which provide information about the way form, material and function are experienced in spatial terms. It is also necessary to investigate if the original concept of the designer did indeed result in the building the designer or client envisaged. Apart from the characteristics of the project, context and building, an architectural analysis should primarily focus on the synthesis of the original intentions of the architect.

As our approach is one of integrated plan analysis, which requires a number of component analyses, we aim to minimise the overlap with other disciplines. Architecture covers all aspects relevant to the design, construction and use of a building: considerations, typology, relationship between the building and its surroundings, overall impression and composition, external and interior choice of materials, and the relationship between the architecture and the load-bearing structure and building services plant. See Figure 240.2.

4.3 Technical analysis

Technical analysis addresses the load-bearing structure, envelope (including the facade), building services plant, unusual technical details, building physics considerations, beneficial and adverse conditions (e.g. dimensional grid, day lighting).

A building is of a high technical quality if the relationships between the load-bearing structure, separations and finishes and building services plant result in a safe building whose users feel healthy and comfortable and are productive. To analyse the quality of a building in technical terms, we consider the following aspects: load-bearing structure, separations and finishes, and climate control.

4.4 Environmental analysis

This analysis considers the effects of choices made in the specifications and design on the environment, including sustainability. Given the variety of buildings to be analysed, Integrated Plan Analysis of buildings requires an instrument which can be applied to a wide range of building types. We selected the GreenCalc+ software package, developed in the Netherlands. This instrument can be applied to offices, schools and residential buildings. GreenCalc+ is based on lifecycle assessment (LCA), a method which considers the environmental impact from cradle to grave, i.e. from the extraction of the raw materials through to eventual disposal as waste. GreenCalc+ calculates the environmental cost of the use of building materials, energy, water and mobility.

The environmental costs can be defined as the societal costs associated with preventing environmental impact. Using a reference building, GreenCalc+ determines an environmental index and a building index. For more information look at : http:/www.greencalc.com.

4.5 Functional analysis

This analysis considers the presence and position of functions, considerations behind these choices (e.g. market demand or architectural considerations), experiences with the use of the building, fitness for purpose and the way it is experienced.

A building is functional if it can be used for the activities for which it was intended. The building users should be effective, comfortable, healthy and safe. This means that it should be easy to reach and enter building and to move about in it. The building should be compatible with the senses: sight, hearing, smell and touch. The building's users should be physically comfortable in it. The building should not be too hot or cold, dirty, dark or noisy. Users should be able to understand the structure of the building and find their way around in it. A range of psychological needs should also be considered such as the need for privacy, social interaction, freedom of choice and autonomy. The building should also be adaptable to changing conditions, new activities and different users.

Van der Voordt and Van Wegen (2000) divided functional quality into seven components. In IPA we have added the component "User perception". This covers: 1. transport and parking; 2. accessibility; functionality; 3. flexibility in use; 4. safety and security; 5. spatial orientation, 6. privacy, territory and social interaction and 7. user experience or perception.

The first four aspects largely relate to utility and the last three to psychological wellbeing. Safety and security includes psychological and physical elements.

4.6 Cost analysis

This analysis considers the initial investment, operating costs, revenues, finance, return on investment, and risk, as well as their structure where appropriate.

Cost control can never be considered in isolation as it is directly related to quality. Costs are not only affected by quality, but also by quantity: floor area (lettable floor area, useful area as a proportion of the total area), m^2 and m^3 of exterior walls, facade penetrations, dividing walls, etc.

Project cost analysis normally addresses the initial investment. The investment includes the costs of land, construction, furnishings and other costs. Control during the course of the process mostly concerns the construction costs and elements of additional costs based on the construction costs. There is a growing need for a better appreciation of the operating costs and their effect on the specifications, design choices and construction. It is therefore appropriate that the emphasis is shifting to the Life Cycle costs: all costs incurred during the life of a building.

In the process as a whole, the decisions in the early stages have the greatest impact on the costs. The opportunities to control the costs are reduced as the process progresses. Cost estimates are a major control aspect. Any cost estimate can only be based on the project information available at the time.

4.7 Process analysis

Here we consider the initial conditions, stakeholder analysis (parties involved in the initial stage, during the development of the plan and during the management stage, and the interest, motivation and responsibility of these parties), and the impact of relevant regulations.

Any building project involves cooperation between autonomous actors with a common objective: creating the building, within the defined constraints of time, costs, quality and regulatory demands. Process analysis covers the development of a building, from the initiative through to the management of the completed building, and the parties involved. This analysis considers who designed, developed and constructed the building, and how, and what factors were relevant to this. We distinguish five stages: initiative; programme and feasibility; design; contract award and construction; use and management. A range of actors are relevant during each stage, with different objectives, interests, responsibilities and resources. These factors may have a major effect on the final design.

Regulations have a major influence on the design and largely determine what is permitted or not. The process analysis themes proposed here integrate the legal aspects in each stage.

Overall, a process can be analysed on the basis of the following aspects: project organisation; initiative; programme and feasibility; design;

contract award and construction; use and management; what was expected and reality.

4.8 Synthesis

Finally, Integrated Plan Analysis produces general conclusions about the project, based on the information provided by the specific component analyses. Here the emphasis is on the overall, the integrated, aspects. Which elements are most or least satisfactory? What could have been done differently or better? Which lessons (general or specific to the project) can be learned from the design and the completed product (i.e. the building) and the process from initiative through to utilisation and management? What are the most noticeable aspects of the building in terms of the present, past and future? The synthesis covers the following aspects: performance; time perspective; conclusions and recommendations (both general and specific to the project).

5. FINAL CONCLUSIONS

Analysis means a division of something into its constituent parts. By contrast, design requires a synthesis of a range or requirements, wishes, values and constraints. An integrated analysis and integrated design require a balanced consideration of all relevant aspects. Certain aspects are relevant to more than one component analysis, e.g. choice of materials, finishes, detailing and daylighting. Furthermore, there are assessment criteria which apply to all themes, such as sustainability and future application. Hence, an analysis of the sustainability of a plan or building requires not only an environmental analysis, but also functional, cost and process analyses. For an existing building we can undertake analyses for different periods: the original situation, current situation, relevant intermediate stages and future potential. In the concluding part of the analysis all the information is consolidated and the major successes and failures are identified.

This approach provides a sliding scale, from a purely objective description and documentation of a building and context through to an interpretation of the facts and their assessment in more subjective terms.

The results of former methods, focusing on one aspect, resulted for instance only in an objective description of the building. The IPA method goes beyond that it slides from context to detail, and all the named aspects.

Depending on the specifics of the building to be analysed, the objective of the analysis, the required resources (time and money) and who analyses the building, the description and analysis will be different in each case. The Method for Integrated Plan Analysis (IPA) for buildings provides a new and comprehensive framework for understanding buildings so that we can learn from them as students, designers, owners, managers, builders, contractors, consultants, etc.

To develop sustainable, durable cities by redeveloping areas we need a tool to analyse the ingredients of the city: its buildings. To really

understand a building and its impact it can be analysed through Integrated Plan Analysis (IPA) proposed here.

6. REFERENCES

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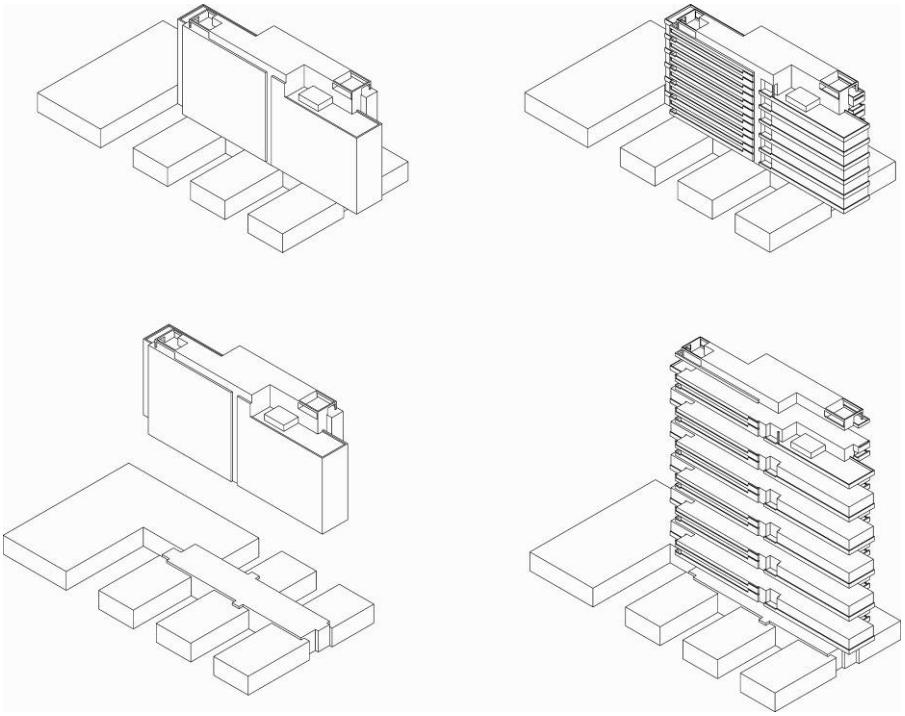
7. CASE STUDY

The building of the faculty of Architecture of the Delft Technical University has been analysed by the IPA method. The next figures will give an idea of the variation of results.

Overall conclusions, developed by IPA, will be incorporated in new plans for the rehabilitation of the building. It is urgently needed because the population increased from 1300 in 1970 till 4000. The concept of the main street inside worked out very well and will be intensified with more functions in future. The load bearing construction was able to incorporate a lot of changes and proved to allow flexibility in floor planning. Only the transparency decreased and needed to be renewed. Durability is generated overtime. Methods as GreenCalc+ need to be updated to be

used with buildings that still are used after 50 years. The judgement of students and employees is still very positive. It is a building with a strong identity.



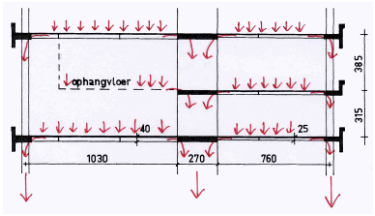
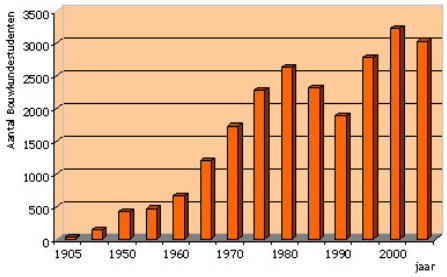
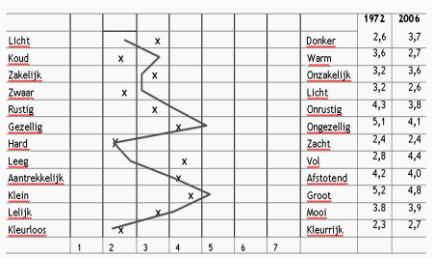
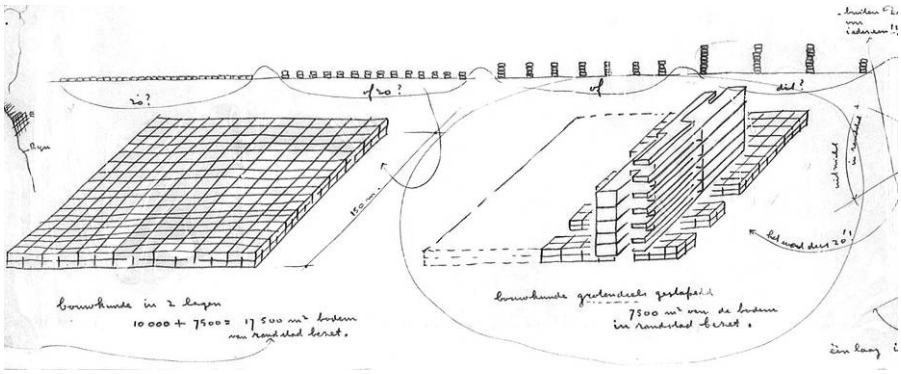


Figure 240.2-9 IPA of the faculty of Architecture, TU Delft: architectonic volume, main street in 1970 and in 2006, load bearing construction scheme, air-conditioning units (foto's and drawings IPA group TU Delft 2006).







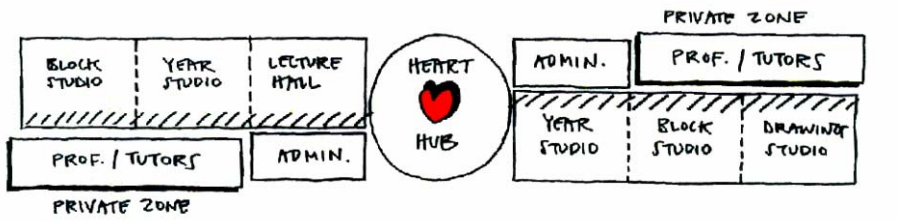


Figure 240.10-14 IPA of the faculty of Architecture, TU Delft: population of students, perception profile, volume study on site, typical floor plan and concept for renewing (foto's and drawings IPA group TU Delft 2006 and NAi Rotterdam).