EFFICIENCY EVALUATION OF THE PROJECT LEVEL OF CAD .

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Importance of the availability of adeguate technical cadres for design

The availability of adeguate technical cadres is a fundamental element for the definition of productive processes. Among these processes, those pertaining to design need higher levels of knowledge. The availability is connected to the training which becomes continually longer and more complex due to the continual rise in the minimum levels of learning. This is due to the development of learning as well as to the increase of the complexity of projects.

High training cost

Training of the technical operator should include both the minimum level necessary for the comprehension of the phenomena and the operative knowledge needed for using the tools available. It is then possible to calculate the cost which, from studies carried out on the problem[1], is already high and tends to become more and more prohibitive as far as time and expense are concerned.

Developing a basic knowledge and discovering new tools widens one's useful learning of the project. If this knowledge is practical and operative for the training, it results in an increase of technician's study load.

Since the main expense is the cost of the teachers, the total costs of preparation increase considerably with the increase in didactic loads.

The result is a training programme which is continually more difficult, lengthy and expensive, with the consequent drop in the availability of adequate technicians.

CAD: How to correct this tendency

Today CAD is mainly part of the introduction of new tools which requires integrative learning . These tools, however, could be a relief for the teacher as far as the basic knowledge of the fields involved are concerned.

There is no need to be shocked: if the objective is to communicate by writing and not compose literature, (as in the past the typewriter made the study of handwriting superfluous and today the new programmes of electronic writing have made the knowledge of spelling become useless) then in the future refined software will be able to transform one's verbal statements into systematized texts, thus rendering useless the knowledge of grammar and syntax.

We also feel that if an objective of the CAD was also to reduce the level of knowledge necessary for the user, one could obtain a simplification of the training process of the technical cadres. Today, the presence of an expert in design processes is requested and justified by the need of the user to access capacities that are not in his possession. In this manner the work procedes all the same with the contribution of the expert. The expert provides for the "ignorance" of the user. A

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1 Comité National pour le Développement des Grandes Ecoles - *Le Coût des Formations Supérieur scientifiques* - su Instantés Terchniques N° 21-22 feb 92 pag 20 - The mentioned study evaluated to 93.450$ the costs for the preparation of a technician with five years formation.

project could even be carried out by a "total ignoramus" if he had experts from each field at his disposal.
This, of course, is not to be the objective.
A CAD can replace the work of a specialist but his does not mean that everything can be substituted, since the whole of all specialists does not create the generality.
The risks of completely substituting man with machine are well known in other more progressive sectors[2] and they certainly cannot he proposed in the building industry.
If it is possible, or will be possible, to balance working with a CAD with the work of an expert, since a CAD replaces the "ignorance" of the user, then this ignorance could be programmed to modify the technician's training.

Additional benefits
The traditional procedure of the creation of a project in the building industry is essentially mass produced: to the general planning of the architect, one must add the work of the structural designer, installer, programmer etc.
The relationships existing between them justify a fundamentally irrational procedure which is however practical for the economic impossibilty of continually working in concert.
If the "expert" is a machine, it can always be at the disposal of the user, and therefore the project process develops at the same time. Theorists of "Engineer assisted by CAD" find this to be a rationalization of the performance[3].
Furthermore, if one does not want to vary the time dedicated to training, the general and problematic studies are restricted by the effect caused by the increase in complexity of the more specialistic aspects.
This was declared by Samuel C. Florman, engineer of problems relating to the study of engineering at MIT. He reports a drop of interest in engineering and notices the necessity of dedicating more time to conceptual studies which are important for the training of the designer.

Today CADs are mainly made by specialists for specialists
It is evident that CADs today do not have this objective. Since they are developed by experts of the field, little attention is given to the problems of use by inexperienced users. A typical example is softs for stress analysis.
Some time ago, at the beginning of the informatics age, Pier Luigi Nervi, when asked about the usefulness of these programmes, replied "they are useful only for those who can can do without". In fact, softs for stress analysis are made to carry out checks that are characteristic of the control phase of the structures. The control operations pertain to the specialist and therefore help him in his work.
As they are now devised, it could be dangerous to interpret these programmes as "replacements" of the specialist and they should be limited to their main performance. They are not designed to help in the structural plan as architects often rely on experts during the preliminar phases of the project.

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2 B. Litlewood & L. Sroghini - I rischi del software - «Le scienze» (293), Gennaio 1993, pp. 24 -29
3 M. Castagné - *L'ingégieur Assisté par Ordinateur*- Commission "Gestion des Technologies" ISP-Instiut Polytechiques de Loirraine - France.

This type of programme should give rapid, vague answers regarding the validity of structural solutions, stress alternative solutions that are more rational, indicate sizes, and highlight the key points to resolve and the eventual complications connected with the various choices.
Consequently, there would be other benefits from this type of programme: a conceptually rationalized finished project for the specialist, whose work would have been made easier and the constructive solution could give more efficient results.

Evaluation systems
If CADs are tools which "help" the project, it is opportune to evaluate them in relation to their actual help, whatever type it is :
- simplifing and making an operation more rapid;
- allowing an "ignoramus" to effect conscious choices.

For the evaluation of the minimum level of learning, if one takes into consideration the risks involved in the use of the tools by an "ignoramus", it is possible to programme a performance which is totally entrusted to the CAD. We feel that an evaluation index of this sort could increase interest in the study of softwares built with this idea. These softwares, even if they go in the direction of exploring the maximum acceptable level of ignorance, at the same time can try to reach more useful goals like a more critical operating way.
With reference to the "Project 90" by Practising Architects Association - Aarhus DK, it explored all the packages of projects in their various phases, recognizing the efficiency of the available informatics aids[4]. This work was aimed to stimulate a direct integration of the aids, thus taking advantage of the enormous benefits of a widespread exploitation of informatics.
A similar type of scheme could be used to investigate the minimum knowledge needed to carry out the operation with traditional equipment. This scheme could become the basic reference.
The CAD will be tested in the filled boxes controlling the semplification and speedy of the operation and the reduction of the level of ignorance consistent with the possibility of making full conscious choices.
The level of efficiency would be noted comparing the level of technical preparation necessary to carry out a specific operation without informatic aids and that evaluated possible with the CAD being examined.

Experimentation with a CAD for the lowering of the level of "ignorance"
In the research of a software with characteristics of decisional support for the designer, we have chosed the unexplored area of the reliability of building elements. This area appeared to be the most suitable to demonstrate the above exposed ideas because in the building process it is not very easy to develop a step that can help to study the reliability of the building components. The duration of these elements, their reliabilty and the difficult of long term forecast, is depens on many factors integration to different kind of competence.

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[4] Proceeding ECADE Conference 1989 paper 2.3.

For this reason for the design choices is necessary the integration of different expertes, coming from fields even very different.

-There are capacities (qualities) connected with the science of materials
-to know which material lasts longer

-there are capacities connected with executive techniques
-to know which method of use renders the material more lasting

-there are capacities connected with the design of building details
-to know which devices should be kept in mind for the design to make the element to last longer

-there are capacities connected with the choice of complementary materials
-to know how to make the building element last longer

-there are capacities connected with the effects of environmental agents
-to know what the effects are of environmental agents on the building elements as far as wear is concerned

-there are capacities connected with historical file codes
-to know what uses of the material and building element proved to last longer

-there are capacities connected with the programming of maintenance
-to know which maintenance procedures make the element last longer.

This problem, among all those in the building field, probably involves more areas of specialistic capacities and experience and definitely has more need of users with a wide spectrum of capacities. If one excludes the experimental laboratory results on durability, the results with useful indications of reliability are principally concise (they are based on observations and overall evaluations) and expressed in various forms which are not directly comparable.
Therefore the initial problems to be faced are two:
- transform concise evaluations into analytical evaluations
- make the evaluations comparable.

We are in a position to affirm that the information necessary to face the problem of durability is difficult to obtain. This assertion, compared to the definition Ruelle gives of "complex" which is "an object (in a broad sense) is complex if it contains information difficult to obtain"[5], gives us an idea of the difficulty in question.

Going on with inaccurancy

Facing the necessity of studying complicated problems, one does not stop at the impossibility of constructing algorithms capable of elaborating data in a deterministic manner or systems of analytical statistics that characterize resolutive casualties.
One studies the possibility of carrying out a certain job taking into consideration if it will represent a useful step in the comprehension of the phenomena (or to make fewer mistakes). The possibility of working even when one all the parts of the problem are not yet clear, was already studied by Henri Poicharé with his studies on the problem of the unforeseeable (1908). He claims that imprecisions in elaborations can be justified and, in fact, he affirms "a very small cause that

5 D. Ruelle - *Hasard et chaos* - Odile Jacob - Paris (1991) cap 22.

escapes us, determines a considerable effect that we cannot see, and therefore we say that said effect is due to chance".
Suppositions in science that cannot be mathematically proved are many, however for this reason they are not rejected but today one attemps to explain them by means to certain types of formulation defined as "vague and imprecise" . Let us try to clarify them by what Ruelle says.
If we visit a modern picture gallery, we will notice a number of wonderful paintings - we will see a Modigliani, a Cezanne, a Picasso! It is the first time we see these works but we do not doubt their authors. But how do we distinguish them? They are not always paintings in which colour is applied in the same way and the subiects vary. There is something else, which is difficult to explain, but which nevertheless is noticed immediately, which could be the choice of forms, the matching of colours etc.
Turning the radio on, we can distinguish, after listening to a few bars of music, whether it is classical or rock music. If we are interested in classical music, we will recognize if it is Bach or Beethoven, Vivaldi or Ponchielli. Even if we have never heard the passage, something unique will indicate to us who the composer is.
One can attempt to identify this something unique by statistical studies[6]. There are intervals of common notes, types and frequencies of intervals that identify them. Listening to a few notes brings us to the same conclusion: the human ear-brain system is a marvellous system of statistical analysis.
In short, we unconciously base our identification of a painter or composer on statistical criteria.
How can one be sure of an identification based on probability?
The answer is that one can be almost certain.
Similary, how can the expert foresee the durability of a building element that he sees for the first time? He observes the elements that he feels contribute to determine its durability, he connects what he sees with what he has seen and analyzed. These elements can be different or similar, each one does not give reliable indications, but in a fraction of a second he is acquainted with numerous elements. The whole does not give him any reasonable doubt, he can formulate an expectation (prevision)
This is the important factor: if one gives a simple, global condition to a complex system, the configurations that satisfy this global condition usually have a group of probable characteristics that distinguish it in a unique way[7].
In our case, the simple, global condition is the evaluaton of the durability of the building component and the group of probable characteristics are the elements that we feel are connected with its durability.

Brief description of the model
Once the problem has been solved regarding the transformation of concise evalutations into analytical evaluations be means of a separation of the observed effect to couples of co-factors and reporting the collecting of data with the

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6 W. Fucks & J. Lauter - *Exaktwissenschaftliche Musikanalyse* - Forschungsberichte des Lande Nordrheim- Westfalen - vol. 1519- Westdeutscher Verlag - Koln - Opladen (1965).
7 It is the principle of the statistical mechanics of equilibrium.

comparision of working parts and weak points, the system realizes a statistical distribution of the scomposed effects.
When making an evalutation, the description of the case by means of the series of identified elements, allows to estract the values connected with evalutation regarding the study case so that the system can make the recomposition that is the foresable duration[8].
By appling the proposed system, refering to the programs of the training courses, it is possible to reach a very good result as long as the user can make with the proposed CAD an evalutation of a building element reliability only by mean of the informations that can be used to describe the building element to be examined.

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8 A detailed description of the model is in: G. Morabito, G. Bellingeri , P. Marrone e P. Trovarelli *CAD for the Analytic definition of Reliability in building process* - «Automation in construction» (6) 1992 - Eselvier- Vol 1 n°1 - pp. 15-20 .