THE SCENARIO AND TRENDS IN THE BRAZILIAN IT CONSTRUCTION APPLICATIONS' EXPERIENCE

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SUMMARY: *IT application in emerging countries faces many specific constraints, not only in infrastructure but also from cultural and economic differences. In Brazil, despite quite satisfactory IT technical education with qualified staff, we have encountered AEC professionals with insufficiently well-developed IT skills, except in CAD systems. This has contributed to a full range of potential IT uses not being considered by the large majority of companies. Most of these companies are small and medium-sized organizations, with limited budgets and technical capacity. The greater part of the market happens to be outside the regulatory context and so, they are not particularly concerned with quality and productivity. The construction sector scenario is therefore reflected in the IT companies, the majority of which are small companies developing customized proprietary systems, thus creating inter-operability difficulties. On the other hand, only a few large contractors have begun to use ERP systems, due to the financial investment and time required to implement them. Besides these barriers, some other factors are also pushing the envelope, requiring more intensive IT use. This is mainly as a response to the formal competitive market that requires quality systems and new trends in documentation and management. To overcome these difficulties some urgent actions have been listed: i.e. improvements in IT education for AEC professionals and cooperative development programs for IT and construction companies.*

KEYWORDS: *scenario, trends, Brazil, IT development.*

1. INTRODUCTION

This paper's intention is to foster greater understanding of IT and its application in the Brazilian construction industry. It is important to note that as an emerging country, Brazil has strong social and economic contrasts. Therefore, some Brazilian geographic, economic and social aspects are highlighted here, in order to explain this situation. In spite of these specific drawbacks, there have been substantial improvements in telecommunication infrastructure, an essential requirement for IT development and use.

Another important issue has been the efforts to improve IT education for AEC professionals and cooperative development programs for IT and construction companies.

Finally some recent efforts by the government in IT education for AEC professionals have also been described below.

2. BRAZIL: DATA AND FACTS

It is important to show some and Brazilian national statistics and data. Its huge territory and rich diversity in climate, people and economic activity is reflected in the huge contrasts between the economically well-developed coastal areas and the poor inland areas with little economic development. Maybe, this sharp contrast is the main characteristic to be found in any Brazilian indicator, from its climate to its social conditions.

2.1 Geography

Brazil is the largest Latin American country, covering nearly half (47.3 percent) of the South American continent. It occupies an area of 8,511,965 sq. km (3,286,470 sq. miles), being the fifth largest country in the world after the Russian Federation, Canada, China, and the United States. On a map of the globe, it can be seen that the eastern bulge of Brazil conforms to the concave curve of the west coast of Africa. The Atlantic Ocean extends along the entire eastern side of the country, giving it a coastline of 7,367 km (4,578 miles). Although 90 percent of the country is within the tropical zone, more than 60 percent of the population lives in areas where altitude, sea winds, or cold polar fronts moderate the temperature. There are five climatic regions in Brazil: equatorial, tropical, semi-arid, highland tropical, and subtropical. Although Brazil is the fifth most populous nation in the world, its nationwide demographic density is low compared to other countries. The population is concentrated along the Atlantic coastal areas of the south-eastern and north-eastern states. Industrial activity is concentrated in the south-eastern region, with 50 percent of industrial production located in Sao Paulo State alone. Migration from the northeast to the southeast, as well as from rural to urban areas, has been particularly heavy since 1970. More recently, the population flow has turned towards the less inhabited central-western and northern regions.

2.2 The Construction Industry and Its Social and Economic Role

Brazil has the largest domestic market in Latin America with a population close to 185 million inhabitants, a GDP around US$ 600 billion and a GDP per capita around US$ 2,800 dollars.

The Construction Industry plays a very important social and economic role in Brazil with 5.6% of the paid salaries and 9% of the human resources and with a final PIB of 19%. Despite these facts, it is one of the less developed industrial sectors, in Brazil in particular, and in the world in general.

In 2003, the sector registered a decline of 8.5 % in economic activity. This may have disrupted recent efforts in the improving industrial performance. During 2004 the construction sector made no gains, but for the present year (2005) the tendency has been for a 5%, expansion, larger than the Brazilian GDP rate for the same period (estimated to be less than 3.5%). In 2003 according to IBGE (2003) there were 119 thousand companies with 1.4 million employees in the construction sector with a specific GDP of 30 billion US dollars. The average salary is 440 US dollars.

Despite its economic relevance, construction has been regarded as a backwater compared to other industries. Construction methods are often poorly chosen, workers rarely are properly trained and onsite supervision and project management are frequently lax. As a result, material waste and cost overruns are pretty standard. The construction industry is largely short of consistent industrial policies, since its growth is often erratic and politically manipulated in order to absorb non-skilled workers.

The industry is highly dependent upon government programs i.e. low-income housing, infrastructure, and other civil works. The high cost of capital, credit scarcity, declining labor wages and public expenditure reduction have slowed construction economic activity, in spite of a housing shortfall exceeding five million units.

As a matter of fact, the construction industry is only responsible for 45% of housing construction. In most cases, houses are informally built and, in the lower income market, informality reaches 84% of the units. High labor taxes and other contribution costs make it almost impossible to compete with the informal sector, unless significant government support is provided. The result is a building industry focused on the higher income market, naturally very limited and exceedingly competitive.

The construction industry is still lagging behind other industrial sectors in their use of information and communication technologies. Globalization and the new world panorama, as well as the current Brazilian scenario of lack of public intervention and under-funding, demand an urgent improvement in productivity and competitiveness in the construction sector (Nascimento and Santos, 2003).

This very specific kind of industry continues to show a relatively low use of Information and Communication Technology (ICT) mechanisms. It is a paradox, in the sense that low productivity leads to a necessary increase in efficiency and competitiveness, areas in which ICT can have its greatest impact and enormous application potential (Nascimento and Santos, 2003). Anyway, it has been noted that progressive steps have been taken by the construction sector, with a number of technological innovations being taken up by companies and thus composing the innovative and competitive strategy for the companies in the sector. Due to the risks and uncertainties of technological innovations, they have not been acceptable to most AEC firms (Toledo et al., 2000) until they have been consolidated and are ready to be adopted by a significant number of companies. The same authors also point out that the multi-disciplinary nature of design and the dependency on the development of new materials and equipment for production are other obstacles to the adoption of innovation.

The Brazilian construction industry is considered very traditional and conservative, mainly as a result of the large public investments it received in the late 1970s, without any specific quality program requirements. This resulted in the lack of commitment to innovation, aggravated by the fact that innovation usually takes several years to be assimilated into the sector (Toledo et al., 2000). Another problem is the workers' lack of formal education, making them less prepared than those in other industrial sectors. Altogether, these issues create barriers to innovation.

During the last decade the scenario has not changed much and nowadays the best program is the National Program for Quality Certification for Construction Contractors (Its abbreviation in Portuguese is PBQP-H).

3. IT INFRASTRUCTURE AND USAGE

Although just 16.6% of Brazilian homes have a computer, and only 21.43 % of them have an Internet connection, IT infrastructure and use is widespread in Brazil. Brazilians are heavy users: the average monthly home usage is an astonishing 18.7 hours (NIC, 2005) an average navigation time even greater than Japan's. Internet access is mainly by the upper social classes (87.15%), whereas just 6.84% in the lower classes. The mobile telephone system has recently experienced a tremendous boom, and now reaches 81 million users, mostly (81%) in the pre-paid card option, preferred by the lower social classes and young people. Fixed lines are in decline, suggesting a preference for the mobile option.

The cost of IT equipment is rather high, especially if compared to average salaries: an entry PC costs approximately US$700.00. Compared to developed countries, the cost of home Internet access is still expensive, ranging from US$14.00 for a 128 Kbps ISDN link to US$95.00 for an 8 Mbps cable connection, still an uncommon service.

In the corporate world IT usage is more extensive, with 98.7% of companies using computers, and 96.4% of them with Internet access. The construction sector is one of the highest users, with 99.86 % using the Internet. As far as e-commerce, 59.66% of the companies utilize it, but 44.22% attribute less than 5% of their commerce to e-commerce mechanisms. It is interesting to note that 79.90% of construction firms use the Internet to interact with the government sector, reflecting the point that the public sector is offering a wide variety of online services.

4. ENGINEERING AND ARCHITECTURE GRADUATION AND IT

Most professionals graduating from Engineering and Architectural schools in Brazil were introduced to 2D CAD and, in many schools, to Solid Modeling, although not always targeted on AEC applications. In addition, most students regularly use e-mail, the web, instant messaging and participate in online discussions using lists or forum mechanisms. They also use office applications.

On the other hand, there are very few graduate Civil Engineering courses in IT on offer at Brazilian universities. IT culture among AEC practitioners is strongest with structural design professionals who have been using number-crunching software for a long time. As regards other professionals, only 2D CAD is highly disseminated

in the sector. A recent survey conducted by the authors shows that most AEC design professionals learned CAD tools in their workplace (45%), followed by formal training (24%) and self-learning (17%).

However, with the falling prices of hardware and good software development efforts, IT skills are being continuously improved in Civil Engineering and Architecture undergraduate courses.

Finally, there are few IT courses for AEC research groups in Brazilian universities with only some specific graduate courses in the area. The main groups can be found at the Federal University of Paraná (UFPR) with its GrupoTIC (a Portuguese acronym for ITC research group - it can be reached at (http://www.cesec.ufpr.br/grupotic) dealing with software development and ITC applications for AEC, such as web-based collaborative project management, nD-CAD and mobile computing; the University of São Paulo (USP) with IT for AEC studies (information retrieval, distance-learning, web services, Virtual Reality, 4D-CAD, CAFM); the Federal University of Rio Grande do Sul (information systems); NITCON research group at Fluminense Federal University (UFF), focus on new IT applications in building; and the State University of Campinas (Unicamp) with some approaches to CAD systems and collaboration.

5. THE PRESENT SCENARIO

In order to give an overview of the professional market, the results of two surveys, dealing with IT use on construction sites and IT use by building design practitioners, are shown.

Moreover, this section endeavors to provide information about academic research groups and their development.

5.1 A Brief Survey of IT Use on Construction Sites

The Construction Industry depends on the use of large amounts of information during the construction phases and for the entire life-cycle of a building. In this context, it is very important that the information is provided to the construction sites in a manner that enables data integration, task control, communication between the company and the suppliers, and material and resource control. This kind of information constitutes the necessary support to allow the engineer to carry out the execution phase within the appropriate budget and without any delays. Therefore, the use of information systems that are capable of improving information integration and communication are fundamental, thus helping the decision-making processes ‘in situ’.

In 2001 and 2005, surveys were carried out to investigate the use of information technology on construction sites, i.e., whether the search for project information that was initially provided by the construction company offices was implemented on the construction sites using IT mechanisms.

The proposed methodology consisted of a survey to obtain structured information, through questionnaires applied directly on the construction sites, in the city of Curitiba.

Curitiba is a city of 1.7 million inhabitants, which is the capital of the Paraná State, in the Southern Region of Brazil, 400 km from São Paulo. Its metropolitan area constitutes 25 cities with 2.5 million inhabitants.

The results presented here are from 16 different construction companies’ sites for the year 2001 and another 16 sites for the year 2005. Most of the sites were for residential buildings (65%) and those construction companies responsible were medium-sized (between 21 to 50 employees on each site).

Despite interest in IT use, most of the companies in this survey (56%) had still not used IT to help or facilitate the site management process. However, these companies realized that IT mechanisms could offer advantages and they were trying to incorporate IT into the construction site management routine. Most of them already had IT devices on the construction site; i.e. a computer with Internet access, a digital camera, and hand-held computers.

According to the survey, communication by telephone was between 94% (2001) to 100% (2005)! The responsible site engineer contacted and dealt with the information flow between the company office and the construction site directly, and by himself. Only a third of the companies used e-mail communication in 2001 and 50% in 2005. The web portals were not used in 2001 and only 17% used them in 2005 to facilitate communication (more data can be found in Figs. 1 and 2).

For the world of construction companies one possible conclusion is that the medium-sized construction sites, with 21 to 50 employees, for residential building, still use IT in a limited fashion. But there is a rising interest in construction companies to improve IT usage and thus reap the benefits.

Please note that this survey is fairly limited and does not correspond to the whole world of construction sites in Brazil or even in the city of Curitiba. Moreover, it has emphasized only one type of construction and should not be taken as a gross generalization.

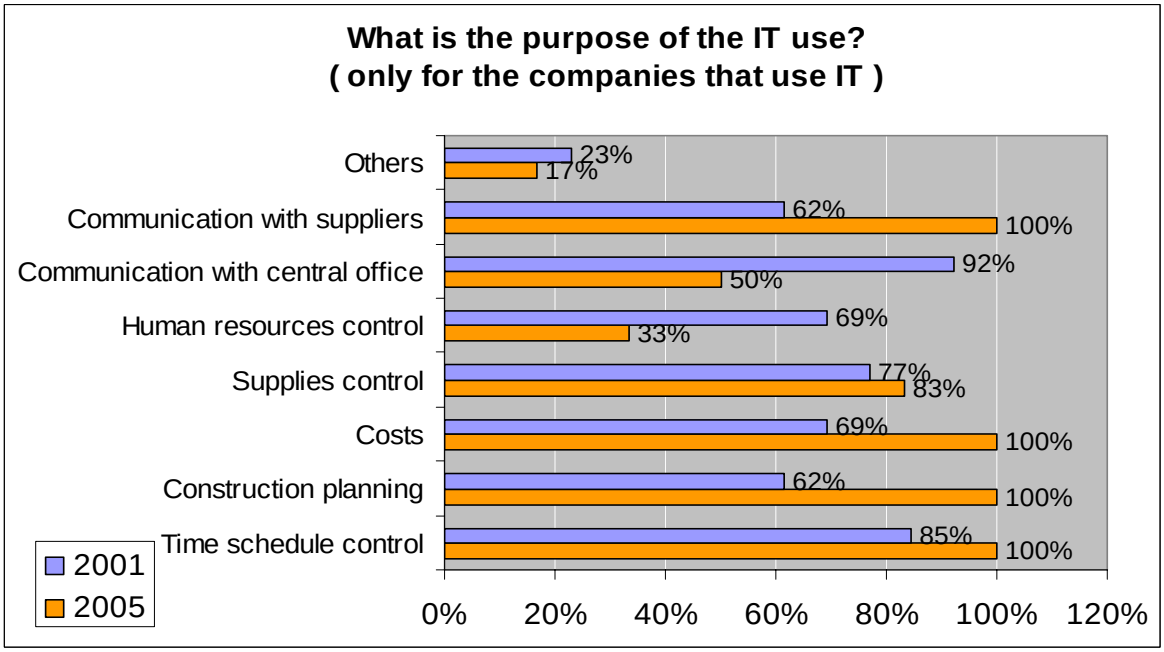

FIG. 1: Communication between Company and Construction Site in Curitiba, Brazil(2001- 2005)

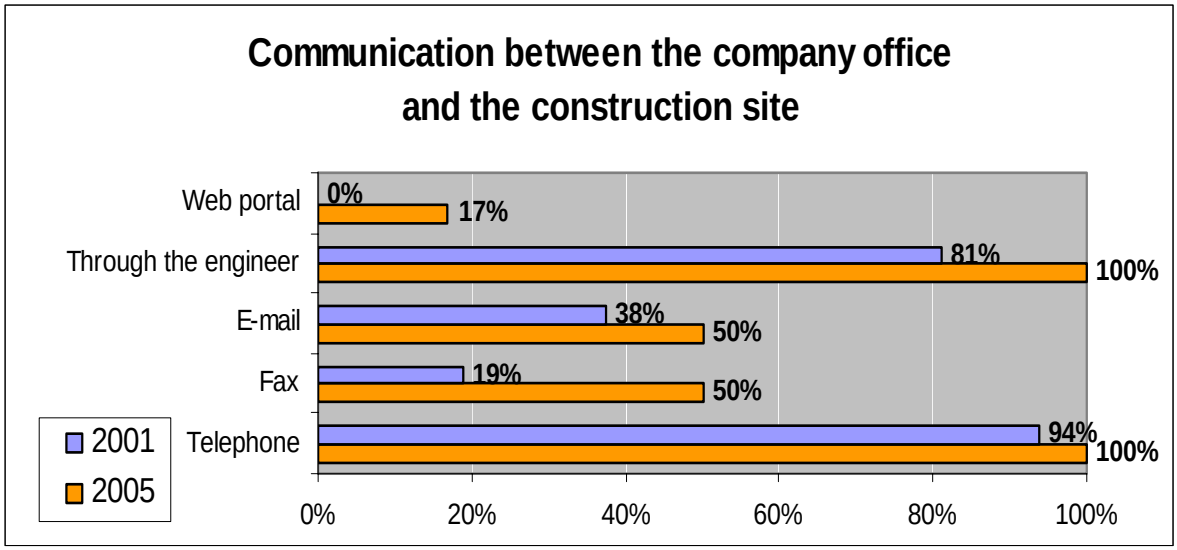

FIG. 2: Purpose of the IT Use on Construction Sites in Curitiba, Paraná, Brazil (2001- 2005)

5.2 A Survey of Building Design Professionals and Their IT Use

Another recent survey conducted by the authors of 30 AEC design offices located mainly in São Paulo and some other major cities in Brazil (Rio de Janeiro, Curitiba and Brasilia) revealed, how IT is used in building design offices (including architectural, structural, electrical, plumbing and landscape design).

The tools, most widely used by these professionals, are AutoCAD (87%) and MS Office (Word: 67%, Excel: 70%). Very few designers made use of scheduling tools like MS Project, as might have been anticipated. All structural design offices surveyed used structural design software from Brazilian suppliers, owing to the need to comply with Brazilian building codes. It can be found many versions of AutoCAD running in these companies,

ranging from the R14 to 2006, indicating they have problems upgrading CAD software; upgrade costs are a major issue for these design offices. These results have been confirmed in other surveys (Manzione and Melhado 2005).

Nonetheless, the IT infrastructure found in these offices was good: two thirds of the design professionals interviewed worked with computers with a Pentium IV or better processor and 76% with 256MBytes of RAM or more; most (55%) have a 17" or larger display and 93% are network connected (although only 87% reported using the network and 73% being able to receive e-mail messages on their computers). One third of the computers found in these offices were very new (less than one year-old). The only operating system found in these offices was Windows, and the Windows XP version represented about two-thirds of the sample.

In regard to communication channels for project information exchange, most designers reported using e-mail, even more than telephone and fax, as shown in Fig. 3.

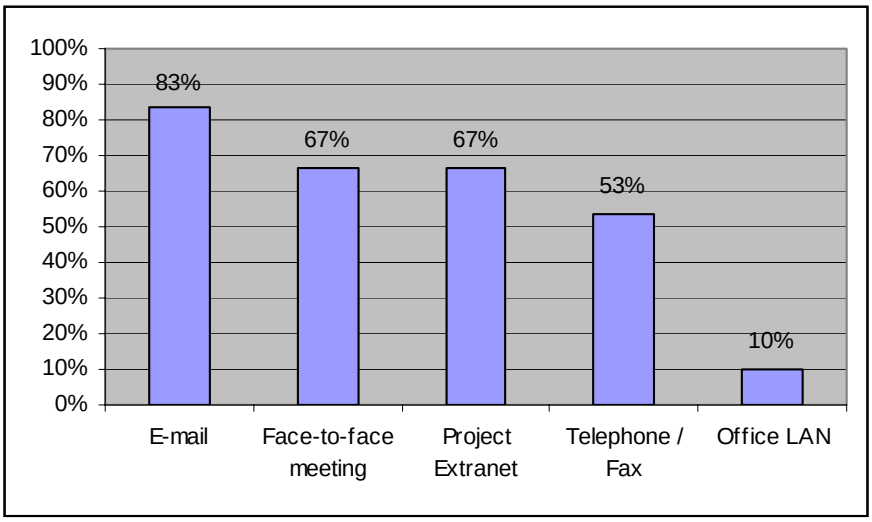

FIG. 3: Most-used communication channels for project information exchange

The design professionals surveyed were experienced in IT use (Fig. 4). Most of them have been using computers professionally, for 10 years or more.

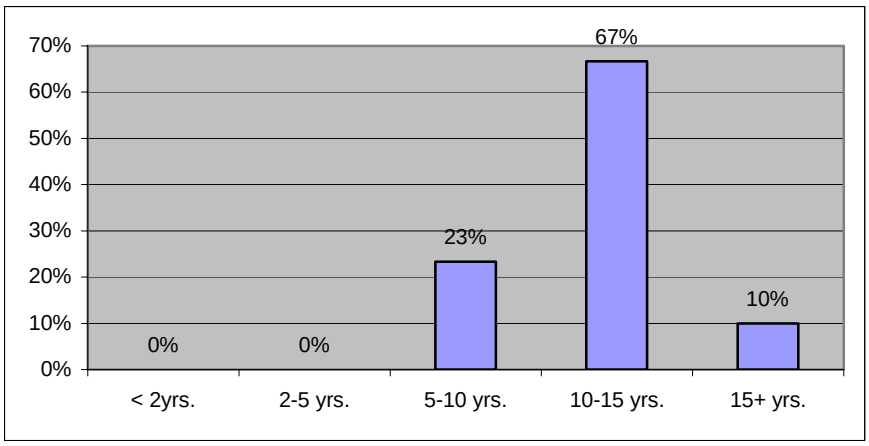

FIG. 4: Years of experience in professional computer use by AEC designers

The survey asked the opinion of designers as to the importance of IT for design activities and on the construction site. Without exception, all acknowledged that IT was fundamental to design work and 87% said that it was important or fundamental on the construction site, revealing that most AEC design professionals, in theory at least, recognize the importance of IT. They also explained why 3D/4D CAD, Virtual Reality and other advanced

tools were not commonly used (Fig. 5). Most people recognized that a cultural problem was the principal reason for the lack of IT uptake, in this sector.

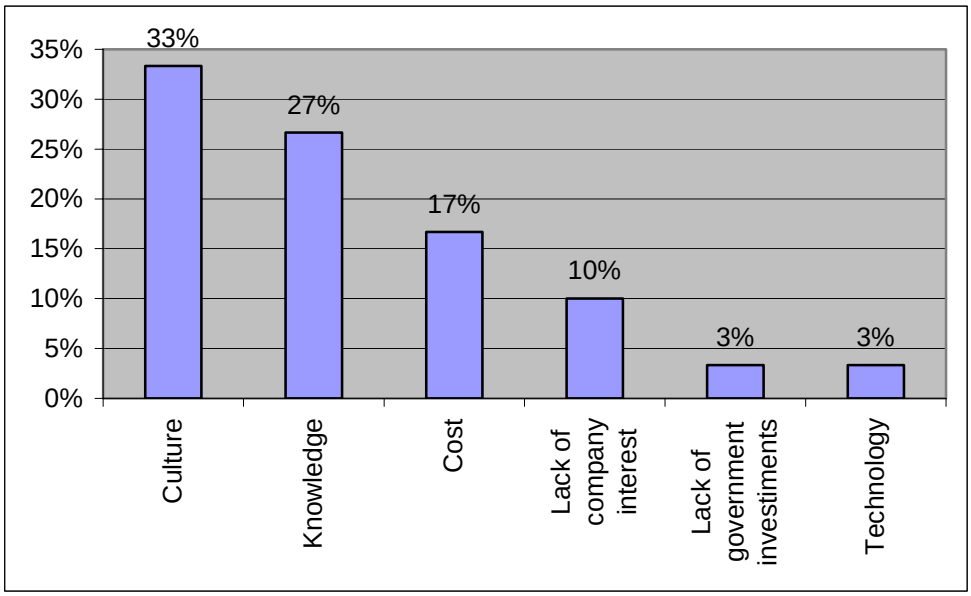

FIG. 5: Perceived causes for the slow adoption of advanced technologies (3D/4D CAD, Virtual Reality) in AEC

From a sample of 29 AEC designers, 83% of them reported not using 3D CAD; their main reasons are shown in Fig. 6. One designer also mentioned the lack of client demand for 3D CAD, as a secondary reason. As these designers are generally not technology users and very few of them are well-founded in this particular technology, we should be cautious when examining these results. We believe the strongest reasons, besides culture, were the lack of integration between 3D design tools and the fact that if most agents in the building design team were not working in 3D, then many of the advantages of 3D CAD were being lost, with reworking needed into 2D-3D conversion and 3D-2D re-conversion.

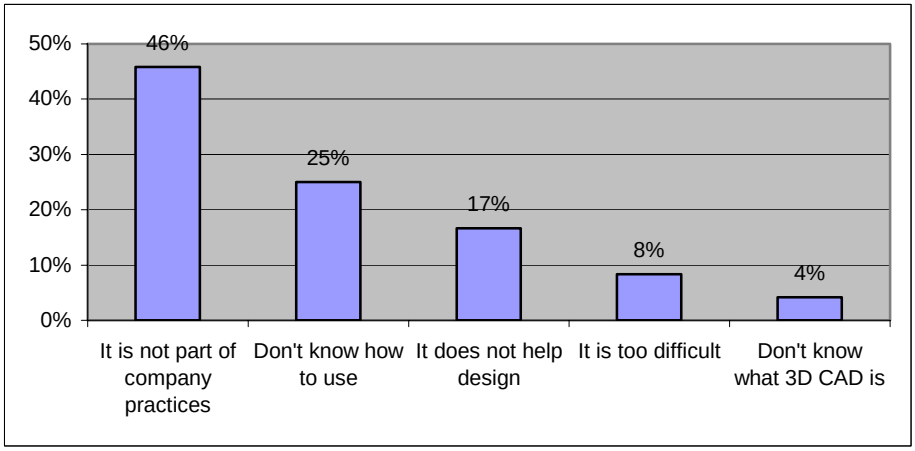

FIG. 6: Respondents main reasons for not using 3D CAD in their activities

As a way of characterizing the sophisticated level of CAD tool usage, our survey asked the users the following questions about the utilization of some of the features commonly found in CAD software:

1. How do you rate you CAD knowledge (basic – 2D only / intermediate – advanced 2D and simple 3D / advanced – programming and/or advanced 3D)?
2. Do you keep drawing information on different layers of CAD files according to a (company / client) standard?
3. Do you usually create blocks and keep a symbol library?
4. Do you use block attributes?

5. Do you use external (or dynamic) references in CAD drawings?
6. Do you quantify using CAD features (instead of doing it by hand)?

The results are shown in Figs. 7 and 8.

Fig. 7 shows that most users reported having an intermediate CAD expertise; i.e. they had good command of 2D features and knew something about 3D modelling; although only few of them were able to program or create complex 3D models.

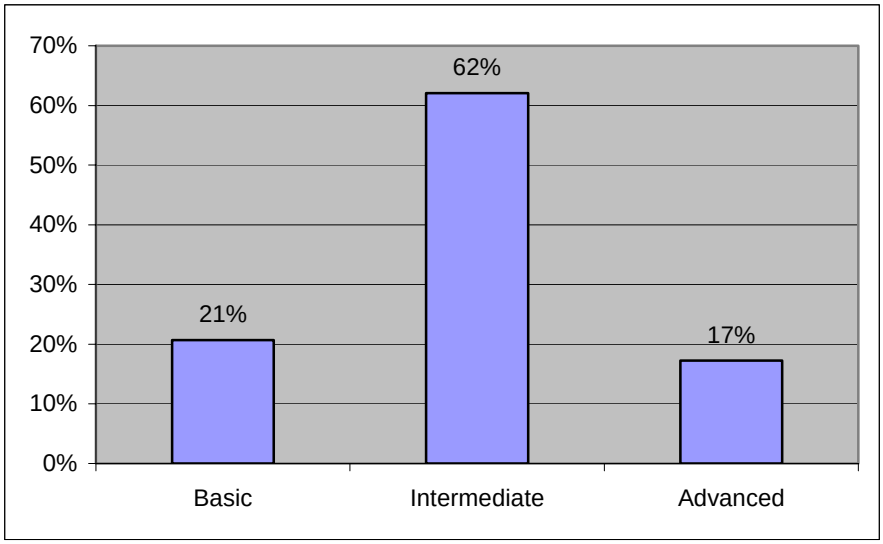

FIG. 7: Self-reported CAD expertise level

The profile illustrated in Fig. 8 shows that most users still used CAD systems only as an "electronic drafting board". The use of layers for organizing CAD files is standard practice now. There is a Brazilian standard (Cambiaghi et al., 2000), ruling layer and directory naming according to design phase and disciplines, which satisfies conceptual conformity to ISO13567. A recent survey by Manzione (2005) found that only 6% of the users in his sample strictly followed this standard and half of those surveyed followed hybrid or internal conventions, for that end. The use of external or dynamic referencing is still small, as is the use of quantifying tools which require better information organization of the CAD files, as well as the use of attributes. This implies that there is still a long way to go, in the use of IFC-related features.

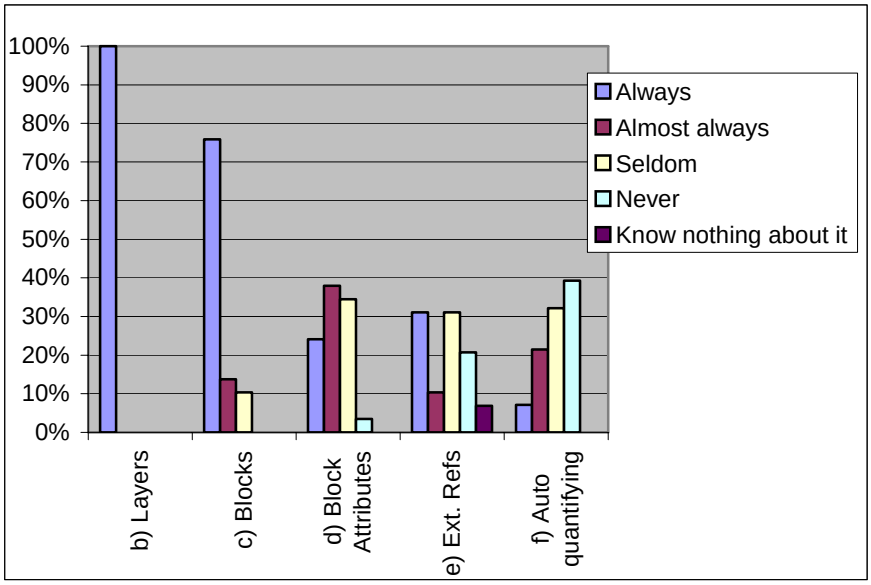

FIG.8: Use frequency of CAD features by interviewed AEC designers

5.3 Academic Research and Development

5.3.1 IT in Construction Research Groups

In the last decade some Brazilian groups devoted to IT in construction have begun to be organized. The table below shows some of those groups.

TABLE 1: Research Groups in IT for Construction and related themes in Brazil

Research Group	Institution	Contact / Leader	IT Subjects
Information and Communication Technology Group (*GrupoTIC*) at the Civil Engineering Research Centre (CESEC)	Federal University of Paraná - UFPR	S. Scheer – scheer@ufpr.br R. Mendes Jr. - mendesjr@ufpr.br http://www.cesec.ufpr.br/grupotic	Information systems and construction management, lean construction systems, collaborative environments, CADnD, distance education
Information Systems Group at the Innovation in Building Construction Research Centre (NORIE)	Federal University of Rio Grande do Sul – UFRGS	C. M. Schmitt - cschmitt@ufrgs.br http://www.cpgec.ufrgs.br/Norie/frame_pesquisa1.htm	Information systems
Product Development Group	Federal University of Rio Grande do Sul – UFRGS	M. M. S. Bernardes bernarde@vortex.ufrgs.br	Lean construction systems
Research Group on Construction	Federal University of Santa Catarina - UFSC	Cheriaf Malik malik@infohab.org.br	Information systems
NITCON Research Group on Applied Informatics to Engineering and Architecture	Fluminense Federal University - UFF	S. L. do Amorim - leusin@civil.uff.br	Specification standards, AEC terminology and ontology, management systems modeling.
Group at the Design Architecture and Building Department	University of Campinas - Unicamp	R. C. Ruschel – regina@fec.unicamp.br http://www.fec.unicamp.br/~regina	Design automation, collaborative design, distance education
Design Support Systems Group at LabCAD.	University of São Paulo - USP	E.T. Santos - eduardo.toledo@poli.usp.br Cheng Liang Lee cheng.yee@poli.usp.br http://toledo.pcc.usp.br/pesquisas.htm http://gepe-sup.pcc.usp.br/	Information systems, CAD, distance education, numerical simulation, information retrieval, virtual reality
Research Group on Applied Informatics to Engineering and Architecture (GRUA)	Regional Community University of Chapecó - UnoChapecó	C. Jacoski claudio@unochapeco.edu.br	Information systems

Some of the most relevant research and products of these groups are described in the following sub-sections.

5.3.2 The INFOHAB / CDCON / NITCON Experience

In 1998 a research group from Fluminense Federal University (UFF), with the support of FINEP, a government agency, and the participation of ten other universities, tried to apply new IT to AEC. The first project was the creation of a Housing Information Center, the www.infohab.org.br, now one of the most important reference services available, with more than 22,000 full-text technical articles and theses, for free downloading. INFOHAB was a laboratory developing many industrial and governmental relationships and brought the discussion of other IT applications into the building sector. It was followed by the CDCON project (2001-2004), which was to have developed a classification system and a terminology database. Unfortunately, this project failed its mandate, mainly because of poor industrial participation. But, slowly, some applications have originated from its studies, such as a specialized full text research engine, to be used by INFOHAB and the main government housing agency, the *CAIXA Econômica Federal*. The natural development of CDCON, now on its way, is an AEC project process ontology. The same UFF research group, with the University of Rio de Janeiro's (UFRJ) participation, also took on the development of a PDA-based application on building quality site management - the SIGMO project - which happened to be used as a prototype, but couldn't be delivered to market, due to a lack of commercial interest and investment.

As we have seen in these examples, the gap between basic university research and product development is one of the greatest hurdles to overcome in Brazil, and not only in the IT field.

5.3.3 Software development for AEC

A research group environment has very specific characteristics ranging from short and long-term projects, pre-defined usage of financial resources, and transitory development teams, to those usually formed by scholastic collaborators. Within this environment, traditional software development methodologies together with an efficient and well-established project management model are not sufficient to gain project success. The human factor (training, knowledge, communication, and team effort) is a major critical project success factor.

5.3.3.1 The ICT Group at Federal University of Paraná

In the year 2000 two staff members of the Department of Civil Construction, and research leaders at the Civil Engineering Research Centre (CESEC) organized an Information and Communication Technology Group for Construction (*GrupoTIC*). Since its inauguration the research group has been devoted to software development and application, producing a number of systems.

One of the main research areas is construction site management. Information as a competitive advantage has great importance nowadays. In the AEC sector the information interchange between the construction site, the construction company office, and the enterprise partners is the main research issue. Important aspects are: communication, document management, and planning and control during construction. Some applied research and software results were:

- **SIGEP** – it is a web environment that provides communication and management for projects and their documents (http://www.cesec.ufpr.br/sigep) (2000-2001).
- **W3P** – planning and control web environment: it implements the integration between the short- term planning (operations on the construction site) and long-term (enterprise) using the Web.
- **Electronic Document Management (EDM)** – through a cooperation agreement that permits the use of a commercial EDM system, applied research was carried out to study building design process management related to the design document life cycle (creation, approval, revision, distribution, storage or destruction) (2001- 2002).

Another topic of research is systems' integration; to carry out research into different aspects of the integration of CAD, CAE and CAPP (Computer Aided Planning and Production). This integration is one of the key points for the Concurrent Engineering where the projects are being developed in a cooperative and simultaneous way. The intended integration is looking for enterprise data models, which represent the product data (Product Data Modelling – PDM or Building Information Modelling (BIM) like the IFC concepts). The research projects are:

- **VisualSite** (2002) – a web environment prototype for integration of 3D design and planning (CAD4D), with synchronized real-time images from the construction site (tele-presence concept).
- **CAD4D/5D and systems integration – towards CADnD** (2004-2007) – this ongoing research intends: to develop guidelines for virtual building prototyping using full 3D design, VR environments, planning and cost estimation regarding the systems' integration; to prepare case studies to apply in the preliminary design phase; and to disseminate the CAD4D/5D/nD concepts and applications in professional education.

ITC and the Construction Supply-Chain was another theme (2002-2003). The research dealt with the influence of effective ITC application in the construction supply-chain, with special focus on logistics and e-commerce; to identify the applied technologies; and to study the ITC implementation process, searching for worldwide trends. These aspects will help in best-practices' educational activities and to build a vision of the future. The main research project report was a survey of ITC practices in Brazil and the world.

Knowledge Management is being studied in engineering companies in order to propose ITC tools to support management knowledge and competencies. The research project investigated knowledge management, and communication and innovation in construction companies (2003-2004).

Finally, Distance Education and e-learning is an important subject. The projects are aimed at developing tools and methodologies for distance and life-long learning at all levels of the Engineering Education. Research projects are:

- **WEB-PG** – management environment for courses and support of postgraduate study disciplines;

- **PRO-CREA** – life-long learning support system for the Engineering and Architecture Professional Council of the State of Paraná;
- **e-Tools** – Cooperative Network for Engineering Learning Objects (http://www.cesec.ufpr.br/etools) and
- **OE3**– Structural Engineering Learning Objects Repository (http://www.cesec.ufpr.br/etools/oe3).

5.3.3.2 Web-based Construction Site Management and Mobile Computing

After the first valuable web system, another software project began. The main objective of the system generated was to service construction site management tasks with information and communication features, through the web (for office use) and to be integrated into a mobile computing operation. Some remarkable characteristics of the process were the required engineering aspects, the implemented lean-construction approach, the prototype development, the spin-off results and the first deliverable innovative version.

The spin-off company has now (2005) been playing in the Brazilian market with the web-based construction planning and management system integrated into a mobile platform based on the PocketPC system (Mendes Jr, 2005). The system requirements were designed during conceptual tests developed together with some university faculties, consultants, construction professionals and some graduate students. The concepts and ideas discussed were implemented and some case studies developed showing the effectiveness of the implemented functionalities.

5.3.4 Brazilian Conferences and IT papers

In the last few years there has been a substantial growth in the number of IT research groups in Brazil publishing papers. These groups regularly publish in some national conferences and journals within the main subject of Construction Management and Economics which is one of the main sub-areas of Building Environment Technology. Pithan et al. (2005) analysed five editions of the National Conference on the Building Environment Technology (ENTAC) carried out between 1993 and 2002 with 258 published articles in the above mentioned sub-areas. During this period the number of papers covering IT themes was about 8% of the total in the previously mentioned sub-area.

In this bi-annual ENTAC Conference, the Information Technology theme is related to new technologies and information management tools used in planning, management, process improvement and information systems' implementation.

In consideration of this, some additional data from other relevant meetings were obtained by the authors showing an increasing number of papers related to IT in Brazilian construction (see Tables 2 and 3).

The tables below represent a summary of this collected data from the four most important conferences in Brazil IT in construction:

- ENTAC – Brazilian National Conference on Building Environment Technology;
- SIBRAGEC – Brazilian Symposium on Construction Management and Economics (since 2005 – Latin American Meeting on Construction Management and Economics);
- TIC – Seminar on Information and Communication Technology applied to Construction;
- WBGPPCE – Brazilian Workshop for Building Design Management.

TABLE 2: National Conference on Building Environment Technology and the Construction Management and Economics sub-area and ITC Related Papers

ENTAC Conference	1993	1995	1998	2000	2002	2004
Number of articles in the sub-area	16	39	95	49	59	80
Number of authors	21	65	143	79	110	135
Number of universities	6	10	23	18	23	25
ITC related papers	0	1	9	3	5	13
% of the papers in the sub-area	0%	3%	9%	6%	8%	7%

Ref.: Pithan et al. (2005) and Proceedings of the ENTAC Conference in August 2006.

TABLE 3: Construct Conferences in Brazil and ITC Related Papers

Meeting	Total	IT articles	% IT articles	IT ARTICLES CLASSIFICATION					
				CAD	Manag.	Planning	Design	Collab. Syst.	Web and standards
SIBRAGEC 2005	183	14	8%	0	5	1	1	0	7
TIC 2005	36	36	100%	5	6	6	6	6	7
TIC 2002	11	11	100%	0	7	0	2	0	2
IV WPGPPE 2004	72	9	13%	2	1	0	1	1	4
III WPGPPE 2003	63	13	21%	1	2	1	7	0	2
II WPGPPE 2002	37	9	24%	1	2	0	2	1	3
ENTAC 2006	488	14	3%	3	2	0	5	2	2
ENTAC 2004	460	13	3%	1	5	0	3	2	2
ENTAC 2002	326	8	2%	1	4	0	0	1	2
ENTAC 2000	370	5	1%	1	2	0	2	0	0
ENTAC 1998	207	6	3%	1	2	1	2	0	0
ENTAC 1995	123	3	2%	1	1	1	0	0	0
ENTAC 1993	99	1	1%	0	1	0	0	0	0
Total	**2475**	**142**	**5,7%**	**17**	**40**	**10**	**31**	**13**	**31**
				12%	28%	7%	22%	9%	22%

6. TRENDS

PBQP-H, the Brazilian building quality program, is pushing almost 2000 of the more dynamic contractors to upgrade their organizations' structure, management and building methods. As a result, within these firms IT use is increasing and nowadays, no building site is without a computer and Internet access. However, this intensified usage brings in its wake many of its own problems. Since there is a lack of established good management practices, there is no software capable of taking a more significant market share. The main producer, PINI, sells around 4000 licenses, in a market that has 110.000 registered firms. Besides this, the available market software has poor functional integration, and in general, just focuses on site control operations or cost control. The firm's main strategy to overcome this problem is to employ customized software, which in fact increases the inter-operability problem (Jacosky, 2003), leading to mistakes and low productivity.

The poor qualification of IT engineers and architects is another critical point (Nunes, 1997). This is particularly obvious, not only in their professional unfamiliarity with IT systems and their potential but also in their poor CAD use, which is limited to a 2D approach and the restricted use of collaborative systems (Nunes, 2004).

From these studies it is possible to identify the main future trends of IT use in the Brazilian construction industry. Firstly, the need for better qualified architects and engineers, fully capable of selecting and utilizing the existing systems' potential; secondly, the increase in the interoperability within different systems and suppliers through better terminology and management standards; thirdly, the development of applications better suited, to fulfill the requirements of the main management standard, in the manner represented by the PBQP-H. Apparently, this is just a market matter. In fact, it depends on the consolidation of management practices, in order to translate them into a modeling system.

Behind these trends we can discern a common cause: the Government's policy that for almost twenty years restricted the Brazilian market; where it was nearly impossible, until 1992, to import the latest technical IT innovations; compromising a complete generation of professionals; and restraining competition and innovation. Just twenty years later Brazil has begun to demonstrate a better IT development ability, especially after the

telecommunications boom which constitutes a solid market with a consistent professional demand that is now starting to spread into the construction industry.

7. CONCLUSION

According to 'The World Bank', Brazil is the 9th largest economy in the world; it has great economic potential; and has an increasing number of possibilities to grow and enlarge this potential in the construction sector. With government and private alliances, this sector can reach high activity levels and the market for AEC IT applications should rapidly follow on the coat-tails of this economic movement. In addition, recently it can be noted important improvements of international investors participation in the Brazilian construction market and consequently more credit availability. This situation might lead to better economic activity levels and innovation processes in the construction industry.

In preparing for this new and growing construction age, one of the most important steps to be undertaken is academic research and professional educational efforts that will continually increase IT use in undergraduate civil engineering courses. Most of the universities now have regular credits in CAD and other relevant IT applications dealing with construction planning and cost estimation.

However, the more intense application of information systems on management projects and works still depends largely on resolving quite complex bottle-necks. It is still feasible to use foreign made tools, such as CAD systems whilst carrying out the project processes (conception) despite local works' and project management characteristics, the limited qualifications of the technical staff and the inadequacy of the local technical culture. This is particularly reflected in development projects, where repeated themes are managed far better through new IT applications.

In order to overcome these hurdles greater integration between the research groups and firms involved in development and commercialization is necessary. This lack of convergence between academic interests and commercial productivity seems to be the weak link in the connectivity between research and development in Brazil. Perhaps, agricultural technology is the only exception to this on-going state of affaires.

This factor is aggravated, specially in the construction industry, as a consequence of the relatively small scale of the construction companies and their IT system suppliers. In particular, in the building sector there are few firms large enough and capable enough to carry out the research, reducing the development market, and consequently the mean size of these companies. One possible solution is a cooperative organization, be it as a research association or for specific projects, with the aim of developing the communication standards and process modelling that could establish interoperability bases, and thus enlarge the markets.

This present picture, lacking in protocol and procedure standards, results in the dispersal and wasted repetition by the different companies' efforts. It can be seen that a huge effort to coordinate these activities is necessary, preferably allied to international initiatives, in a manner that allows national groups to remain competitive whilst a more open market is being established.

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