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الملخص

تتعرض صناعة التشييد بطبيعتها إلى عدد كبير و متنوع من المخاطر وتهدف هذه الدراسه إلـى وضع إطار عام لنظام خبره يسهل حساب هذه المخاطر بناء على رأى الخبراء و فى هذا الأطار تم وضع نموذجين لتحليل المخاطر:

النموذج الأول :

تحليل مخاطر التشييد باستخدام التحليل الأحتمـالى و هـو نمـوذج يعتمـد علـى تقسيمة العوامـل المؤثره فى المخاطر الى مجموعات متسـقه ثـم تحليـل هـذه المجموعـات باسـتخدام أسلوب المحاكـاه للوصول إلى الناتج النهائى و قد تم وضع برنامج حاسب آلى لدراسة هذا النموذج.

النموذج الثاني :

و هو نموذج يمثل المخاطر فى خمسة أبعاد هى :

(الأمكانيات و الأحتمالات و الأهميه النسبيه و الأعتماديه و الوراثه)

و هذه الأبعاد متمثله فى صورة لغه طبيعيه و ذلك باستخدام نظرية المجموعات المبهمه

التوصيات :

توصلت الرساله الى عدة توصيات أهمها :

**التوصيه بدراسة عماية تجميع المتغيرات العشوائيه فى نماذج التحليل الأحتمالى

**التوصيه بإعداد دراسه متكامله للوصول الى تمثيل اللغه الطبيعيه من خلال نظرية المجموعات المبهمه

**التوصيه بإعداد نظام خبره متكامل لدراسة مخاطر التشييد

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ZAGAZIG UNIVERSITY
FACULTY OF ENGINEERING

CONSTRUCTION RISK ASSESSMENT USING FUZZY SET THEORY - AN INTRODUCTORY COMPUTER MODEL FOR EXPERT SYSTEMS

BY

Tamer El-Sayed Mohamed El-Diraby

(B.Sc. Construction Engineering, Zagazig Univ., 1989)

A Thesis Submitted in Partial Fulfillment for the Requirement of the M.Sc. Degree in Construction Engineering (Civil Eng.)

Supervised By

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1993

بسم الله الرحمن الرحيم

"وقل ربى زدنى علما"

صدق الله العظيم

EXAMINERS COMMITTEE

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INTRODUCTION

Variation, uncertainty and risk are ever dominant characteristics of the construction industry. Each construction project has its own features that make it unique, though they all share the common dilemma of managing risks of uncontrollable, yet predictable factors governing the construction environment and the total project output. These factors range from natural ones like weather, to psychological ones like motivation, to country wide factors like market conditions.

In the last few years construction industry all over the world propagated to an extent, that it may now be considered the world's largest industry, this propagation added to the susceptibility of the industry to the variation and uncertainty of its ingredients. The construction industry investments now presents a larg proportion of the GNP of many countries, more and more complex projects are being executed, multi-disciplinary projects whose cost are in billions of dollars are executed daily all over the world. All these considerations make risk analysis the back bone of any feasibility study in the construction industry.

By world war II the era of simulation and probablistic analysis moved the concept of deterministic analysis out off the stage. Risk analysis studies and models based on probablistic analysis propagated both in volume and complexity .However probability analysis failed to deal with some important ambiguous qualitative elements that can be either ignored, nor presented as a probability distribution such as skill, motive ... etc. Fuzzy Sets Theory presented the solution to deal with qualitative elements. The use of Fuzzy Sets Theory in knowledge acquisition revolutionized the era of expert system and neural nets which are the state of the art nowadays in the field of construccttion risk research.

Construction managers, faced with a highly changing environment, and new types of risk-political, economic,...-cannot make much use of the previous models of risk analysis because most models are very specialized to solve a certain problem within a predefined scope, the models produced till now lack a unifying vector to combine its efforts and to guide its growth.

1.1 Study Scope :

This study is an attempt to propose a general layout for a Construction Risk Expert System "CRES", an expert system that is :

* General yet simple
* Flexible and context independent
* Able to build experience over time.

In order to achieve this goal, a general framework for the expert system is proposed in chapter III. Furthermore, two models are proposed to support the expert system, the first "Construction Risk Assessment Using Probability Analysis" "CRAP" is a context independent probability analysis model utilizing the Monte Carlo Technique, it can assess the riskiness of any risky element as long as it can be sorted into small ingredients called "Factors" expressed as a probability distribution. A new correlation scheme dividing correlation into "Co-occurrence" and "Co-consequence" is presented to help the user to express his attitude without any restrictions.

The second model "Construction Risk Assessment Using Fuzzy Set Theory" "CRAF" is an attempt to use Fuzzy set theory to process natural language, and to form a special semantic for risk analysis. The model presents each risky element as a collection of an arbitrary number of factors each of them is presented in five fuzzy dimensions-Possibility, probability, importance, dependency, and inheritance-, these dimensions

simple manner to allow the user to freely express his attitude.

the two models are aimed to be the nucleus for further studies, they were designed to be general and simple just like the CPM in planning.

1.2 Thesis Organization :

After the introduction, chapter (2) discuss the nature and types of uncertainty and risk, the major works in the field are also reviewed in brief. Chapter (3) presents the need and the general framework for the proposed expert system "CRES". Chapter (4) presents the first model "CRAP". Chapter (5) presents the second model "CRAF". Chapter (6) is devoted to the conclusions and recommendations for further studies.

CHAPTER 2

RISK, UNCERTAINTY AND CONSTRUCTION

The construction industry is characterized by its polymorphic risky nature, risk and uncertainty surround almost every thing in the industry. These risks can arise due to various reasons, they may be endogenous to the industry or exogenous-caused by external environment- Oscillating the industry in a fictitious circle of risks and risks generated by other risks. These risks may be sorted as shown in (Table 2.1).

Being such a multi-criteria problem, construction risk researches necessitate the coorporate utilization of a vast number of theories and techniques such as Probability Theory, Utility Theory, Theory of Games, Decision Making, Simulation and Computer Modeling, and Fuzzy Set Theory. Consequently the research in this field has propagated into more finer specialties such as risk assessment, risk analysis, risk management,.... etc. Fig (2-1) shows the spectrum of risk research as viewed by **(B.W. Boehm, 1989).**

2.1. Definition of Risk :

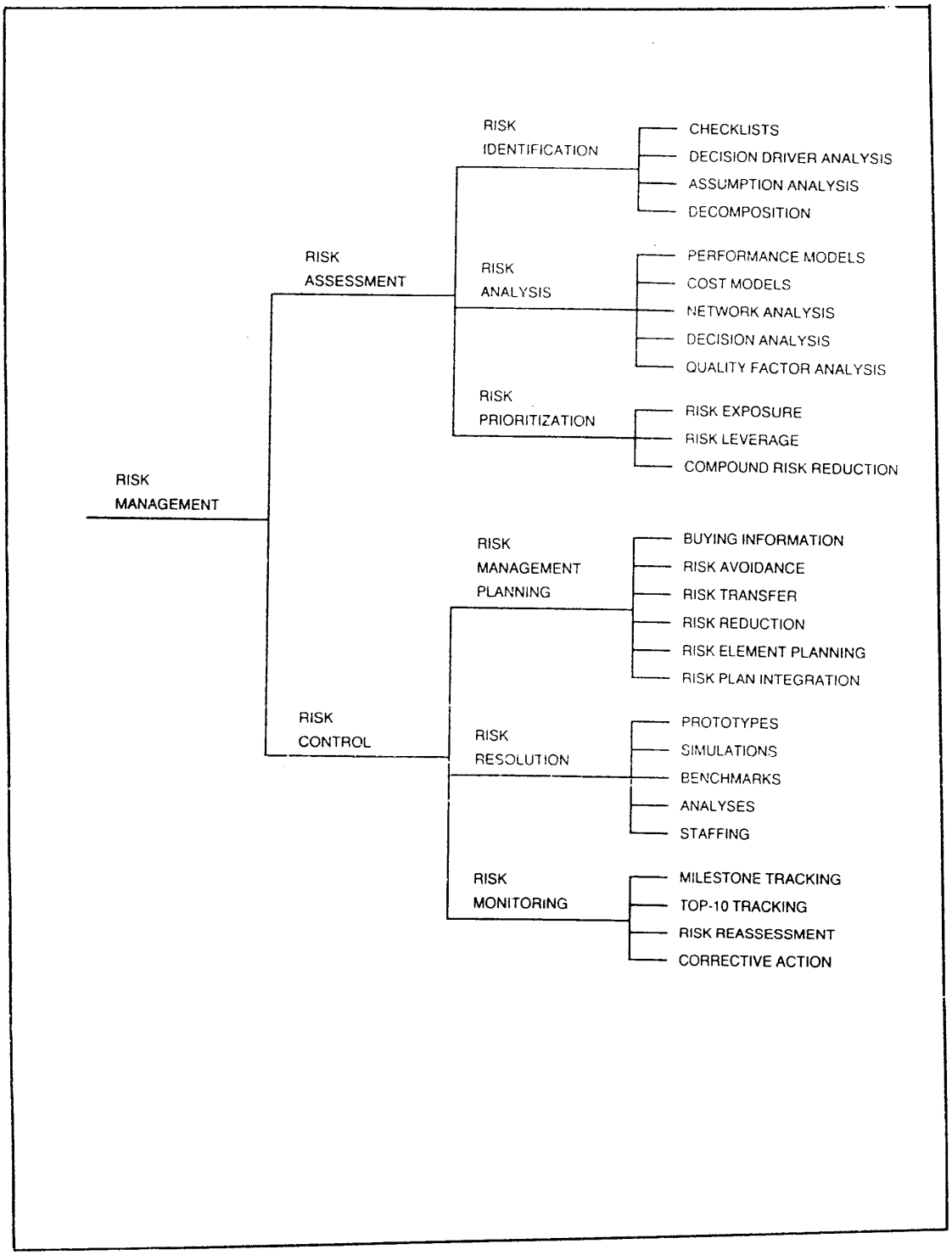
Risk is the exposure to the possibility of economic or financial loss or gain, physical damage or injury, or delay, as a consequence of the uncertainty associated with pursuing a particular course of actions.

Table (2-1) : Sorting Risks by Cause

Risk Cause	Risks
Act of God	Flood Earthquake Land Slide Fire Wind Damage Lightning Weather Soil Conditions
PHysical	Damage to Structure Damage to Equipment Labor injuries Material and Equipment Fire and Theft
Financial & Economic	Inflation Availability of Funds from Client Exchange rate fluctuation Fluctuation Default of Subcontractor Non Convertibility Market Conditions Country Economic Situation Country Financial Situation Bond Policy in Banks
Design	Incomplete Design Scope Defective Design Error and Omissions Inadequate Specifications Design Change
Job Site Related	Labor Dispute and Strike Labor Productivity Defective Work Equipment Failure
Site Restriction	Land Scape Soil Condition Traffic

Table (2-1) : Continued

Resource	Waste Handling Price Change Storage
Managerial	Skill Control level Training Staff condition
Psychological	Motive Efficiency Accomodations
Political & Environment	Change in Laws and Regulations War and Civil Disorder Requirment for primitis and their approval Pollution and Safty rules Expropriation Embargoes World Wide Danking Condition



Fig(2-1) Risk Analysis Reseach Spectrum.
(Boehm,1989,pp2)

2.1.1 Risk Assessment :

It is the process by which our data and knowledge or cognition about a risky element are presented-subjectively or objectively-in the form of a randomly changing probability distribution, or a linguistic variable. Assessing risk deals with transforming our knowledge and experience about an element into some sort of mathematical form usable for any further analysis, this process depend on many factors, such as :

1. Assessor's personal characteristics
2. Assessor experience
3. Type and nature of risky element
4. General project condition
5. General company conditions
6. General market conditions.

2.1.2 Risk Analysis :

It is the process in which different presentations of risky elements-in the form of a probability distribution or a linguistic variable-are aggregated to evaluate their combined effect.

2.2 Uncertainty :

Since Heizenberg **(L.I. Ponomarev, 1988)** introduced in 1927 the

"Uncertainty Principal" to the nuclear science and later to the general theory of relativity, our prospective to each piece of data and knowledge has shaken strongly to adapt with a complete new era of human thinking based on relativity and uncertainty which form a soft membrane of vagueness and ambiguity that surrounds our scientific life, knowledge and thoughts in our ultra-bluring environment.

Gupta (1988) divided uncertainty into two types, the first he called U-type one, where U stands for uncertainty. The U-type one uncertainty deals with the information or phenomenon which arises from the random behaviour of physical systems. "The pervasiveness of this type of uncertainty can be witnessed in the random vibration of a machine, random fluctuations of electrons in a magnetic field, diffusion of gases in a thermal field, random electrical activities of the cardiac muscles, uncertain fluctuation in the weather pattern, and the turbulent blood flow through a damaged cardiac valve".

In other words what deals with systems of variable rather than deterministic nature. The characteristics of the system are randomly changing according to a given probability distribution. but on the other hand, the domain of knowledge of the system variability is known. We

can define this type as an "imperfect case data" type i.e. which one value-of a pre-given sum of values-represent the instant value of the variable. This type depends on the availability of data in the form of hard digits and probability distributions, these data source may be a subjective or an objective judgement. A large number of studies has dealt with this type of uncertainty using the rich literature of the theory of probability and statistics. In fact this type produced a separate branch of science that is simulation, which uses probability distribution as input to simulate a natural phenomenon or a system.

The second type arises in the case of "imperfect domain of knowledge "i.e. when one cannot give a sharp boundaries to determine where the instant value of a variable exists, or what **Gupta (1988)** calles U-type two". The U-type two uncertainty, unlike U-type one, is the uncertainty that deals with the phenomena arising from human thinking, reasoning, cognition, and perception process, or cognitive information in general. This is a subject which has been either neglected or taken very lightly. The cognition and perception of the physical environment through our natural sensors (eyes, ears ... etc), the perception of pain and other biological event through our nervous system, and neural networks deserves a special attention.

The perception phenomenon associated with these process are full of "uncertainties" and cannot be characterized by conventional statistical theory. We can feel pain in the back but this pain can be neither measured nor characterized using statistical theory. Similarly we express our perception linguistically "this red flower is just beautiful and is full of pleasing fragrance", this corresponds to the "perception" of our physical environment where "red" and "beautiful" describe the visual perception, whereas "pleasing fragrance" describe the perception of smell. Again we can not characterize these perceptions using the strength of the statistical theory". This is the kind of uncertainty which human brains deal with, our brains fail to multiply two number of three digits, yet it can, in a fast manner, identify, analyze and process such ambiguous variables such as, bad weather, high skill, ...etc, the brain can process these variables and gets a cognition about the final result of a combination of these linguistic variables. Traditional methods like simulation fail to analog these tremendous features of brain, because they deal only with hard number crisply located in a domain of knowledge, yet they fail to deal with linguistic variables that represent experience that experts gained over the years. So another technique was required, which can deal with imperfect domain of knowledge, linguistic variables and ambiguity. **Zadeh (1965)** proposed the concept of Fuzzy Sets, which

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رسالة مقدمه
للحصول على درجة الماجستير فى هندسة التشييد

م/ تامر السيد محمد الخريبى
بكالوريوس هندسة التشييد - جامعة الزقازيق ١٩٨٩م

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