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From the Chief Author's Desk

We see a drastic momentum everywhere in all fields now a day. Which in turns, say a lot to everyone to excel with all possible way. The need of the hour is to pick the right key at the right time with all extras. Citing the computer versions, any automobile models, infrastructures, etc. It is not the result of any preplanning but the implementations of planning.

With these, we are constantly seeking to establish more formal links with researchers, scientists, engineers, specialists, technical experts, etc., associations, or other entities, particularly those who are active in the field of research, articles, research paper, etc. by inviting them to become affiliated with the Global Journals.

This Global Journal is like a banyan tree whose branches are many and each branch acts like a strong root itself.

Intentions are very clear to do best in all possible way with all care.

Dr. R. K. Dixit
Chief Author
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Modeling Of Earthquake Ground Motion for Tbilisi Region

P. Rekvava[1]k. Mdivani[2]

GJRE Classification – E (FOR) 090702, 090504

***Abstract*- A method is presented for elaboration parameters of seismic action on the territory of Tbilisi region. This study has taken into account stochastic nature of earthquakes. Some steps are considered to generate a synthetic ground motion accelerogram compatible with a response spectrum. A mathematical model to simulate ground motion processes is proposed for which both intensity and frequency content are non-stationary. The simulated time histories fit the recorded accelerograms in terms of several ground-motion amplitude measures, such as Peak Acceleration, Fourier Spectra and Response spectra. The method consists in correlating the simulation parameters with earthquake magnitude, source distance and soil conditions.**

Keywords-Ground, Motion, Seismic, Stochastic, Accelerogram

I. INTRODUCTION

In the practice of earthquake engineering the seismic action usually is represented by an elastic ground acceleration response spectrum and by the ground acceleration time-histories.

Direct dynamic method or time-histories dynamic analysis provides the evaluation of seismic demand of structures using the artificial and recorded or simulated accelerograms that give information on earthquake intensity, its frequency content and duration, i.e. it does not exclude time factor as it occurs in the response spectrum method. Moreover, the design accelerograms used for seismic design are scaled according to the maximum peak accelerations value of the design and Maximum Considered Earthquakes (MCE).

It should be noted that, each earthquake represents individual process, which is generated under certain geographic and geological conditions. Earthquake destructive effect first of all depends on the magnitude and the epicentral distance, but the elastic response spectrum shape depends on the earthquake generation mechanism and ground response in the site of interest.

Therefore, the elastic response spectra defined according to the recorded accelerograms in different regions, differ from each other and reflect only local site conditions.

Proceeding from the regulations on seismic action basic conception given in the EC8 (European Standard EN 1998-1:2004), selection of the elastic response spectrum shape in the country or part of the country is possible from the certain country National annexes that are worked out by local Authorities. In accordance with the recommendations suggested by EC-8 deep geological data of the construction site should be considered and the horizontal and vertical elastic response spectra should be computed taking into account the seismic sources and the earthquake magnitudes generated from them. Herewith, the elastic response spectrum shape for two levels of seismic action may be taken the same.

It will be noted that, the seismic history of the capital of Georgia – Tbilisi is concerned with seismic active region of the Caucasus, in the centre of which it is located. This circumstance considerably defines the fact that among the cities of the Caucasus Tbilisi even today keeps one of the first places according to the quantity of felt earthquakes. These earthquakes sources are originated in the different regions of the Caucasus and regarding Tbilisi are classified as the regional and local earthquakes.

For Tbilisi region (within 50 km) records of the strong earthquakes data are limited. During last 100 years at the city of Tbilisi territory about hundred weak earthquakes took place. Local strong earthquake occurred only on April 25, 2002, under the central part on the city with magnitude M=4.5 but very shallow focal depth of 3 to 4 kilometers, and recorded peak horizontal acceleration on the bed rock of 0,11g, which was amplified to the range of 0.20 to 0.30g due to dynamic response of surface soil deposits. The peak vertical horizontal acceleration equals 0,04g.

At the same time, lack of the strong real earthquakes records creates some problems for the elastic response spectra definition. On the basis of the weak and rare earthquakes real records, formation of the seismic action specified regional model is impossible. In such conditions the most straightforward procedure is to generate ground motion time histories using of regional earthquake sources zones parameters and classification according to the soils seismological and geological properties spread at Tbilisi territory.

For the past years, many seismological and engineering methods have been suggested for simulating ground motions, which estimate the ground motion in fundamentally different ways (Housner and Jennings, 1964; Saragoni and Hart, 1974; Eisenberg, 1976; Vanmarke, 1980; Shinozuka and Tan, 1983; Aktinson and Somerville, 1994; Sabetta and Pugliese, 1996; Boore, 2003; Pousse et al., 2006; Amiri et al., 2008; Rezaeian et al., 2008).

The stochastic and deterministic models are used in the seismological approach. They usually require the knowledge of many parameters, characterizing the source rupture process and the travel path of the seismic waves.

The stochastic and empirical models to the simulation of ground motion are utilized in the engineering approach. These models do not need to make use of specific geophysical parameters, but the resulting time histories are in general poorly correlated with magnitude and distance from the source. The simulation procedure typically consists of multiplying a deterministic modulating function with a stationary process of known power spectral density.

This study focuses on the developed model to assess the ground motion of the credible earthquakes in Tbilisi region,

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considering the seismological and geological properties for the site of interest, based on the approach proposed by the first author of this paper (Rekvava, 1994).

II. Determination of the Parameters of Ground Motion for Tbilisi Region

Data of Table 2.1 obtained at twelve earthquake sources zones of Tbilisi region (Varazanashvili 1999), that can reveal maximum seismic effect on the territory of the city of Tbilisi, were taken as the basis for evaluation the parameters of expected ground motion in the city, such as dominant period T, effective duration D and maximum horizontal acceleration $A_{h.}$

Empirical relations between the above-mentioned parameters, a surface-wave magnitude of the earthquake M and a hypocentral distance R derived for shallow-focus near-source earthquakes under an average soil site conditions are given by the following expressions (Rekvava, 1994)

$$\lg T = 0.15M_{max} + 0.25\lg R - 1.9 \quad (2.1)$$

$$\lg D = 0.20M_{max} + 0.50\lg R - 1.3 \quad (2.2)$$

$$A_h = 5600(R+40)^2 e^{0.8M} \quad (2.3)$$

Table 2.1. Parameters of Earthquake Source Zones

Zone No.	Surface magnitude M_{max}	Focal depth H , (km)	Minimal distance from the zone d_{min}, (km)	Expected maximum Intensity in the zone I_{0max}, (deg)
1	6.0	10	20	8
2	7.0	15	30	9
3	6.0	10	15	8
4	6.0	10	0	8
5	6.0	8	0	8
6	6.0	10	20	8
7	7.0	15	30	9
8	5.5	8	30	8
9	5.0	8	15	7
10	6.0	10	0	8
11	6.5	10	15	9
12	6.0	10	10	8

Using Eqns. 2.1-2.3 and the computer code "TBILISI" for given earthquake characteristics from Table 2.1, the seismic ground motion parameters were determined. Values of these parameters are listed in Table 2.2. It should be noted that, the vertical acceleration A_v is accepted 70% of A_h .

Table 2.2. Quantitative Characteristics of the Ground Motion Expected in the City of Tbilisi

Zone No.	R (km)	T (sec)	D (sec)	A_h (m/sec^2)	A_v (m/sec^2)
From focus with M=5.0					
9	17.00	0.14	2.07	0.94	0.66
From focus with M=5.5					
8	31.05	0.20	3.65	0.84	0,59
From focus with M=6.0					
1	22.36	0.22	3.76	1.75	1.22
3	18.03	0.21	3.37	2.02	1.41
4	10.00	0.18	2.51	2.72	1.90
5	8.00	0.17	2.25	2.95	2.06
6	22.36	0.22	3.76	1.75	1.22
10	10.00	0.18	2.51	2.72	1.90
12	14.14	0.19	2.99	2.72	1.90
From focus with M=6.5					
11	18.03	0.24	4.25	3.01	2.11
From focus with M=7.0					
2	33.54	0.34	7.29	2.80	1.96
7	33.54	0.34	7.29	2.80	1.96

III. ENGINEERING GEOLOGICAL AND ENGINEERING SEISMOLOGICAL CHARACTERISTICS OF LOCAL SITES OF THE CITY OF TBILISI

The capital of Georgia Tbilisi stands on the banks of the river Mtkvari in a valley surrounded by hills. Its entire area totals 350 sq. km. The mountain rocks are the main elements of Tbilisi engineering-geological conditions. They define the relief character, compliance to geological processes, spreading and character of subsoil waters, and they represent the natural basis of building and structures.

Proceeding from peculiarities of engineering-geological and geomorphologic conditions of Georgia, in National Code (BC" Earthquake Engineering" 01.01-09, 2009) the classification of the soil seismic properties by 4 categories is made more precise. The particular attention is paid to characteristics as are: lithological description and the average shear wave velocity, $V_{s,30}$.

In earthquake engineering design practice the territory of the city of Tbilisi according to the Georgian seismic hazard map (BC" Earthquake Engineering" 01.01-09, 2009) belongs to the zone of seismic intensity 8 by MSK-64 with maximum horizontal acceleration 0,17g (the 2% in 50 years) and most of the soils, spread on this territory (about 60%), belong to the average or category II with a shear wave velocity between 360 and 800 m/sec.

Proceeding from research goal, on the territory of the city (see Fig. 3.1) were selected and investigated by way of boreholes arranging 10 local construction sites whose soil type, physical-mechanical properties and the average shear wave velocities were determined.

The soil seismic properties on the sites under examination were defined based on the experimental investigation of mechanical effect due to falling load, employing the method of reflected seismic waves (Rekvava and Mdivani, 2010).The mentioned method implies the determination of the seismic longitudinal V_p and shear V_s waves velocities and seismic rigidities of the soil layers. Then the seismic category or types of the construction site main soils are established correspondingly to values of the velocities V_p and V_s, and a density of the soils and the site influence factors Sf are calculated.

Thus, on the territory under investigation according to of the EC8 the average shear wave velocities $V_{s,}30$ in the upper 30m of the soil profile were made more precise and the elastic response spectra were constructed

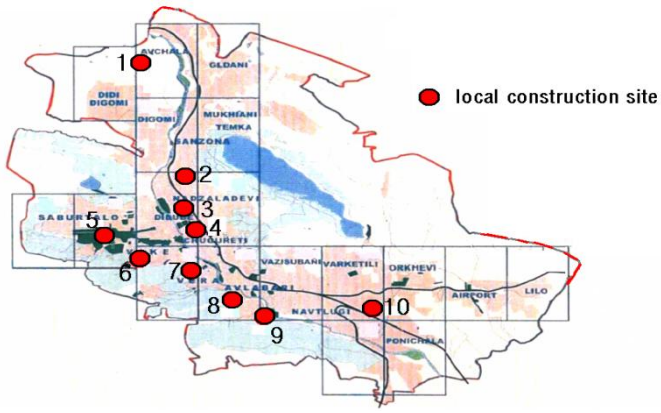

Figure 3.1. Location of the boreholes on the territory of the city

As an example, In Fig. 3.2 are illustrated the elastic response spectra of the first and second types calculated for the construction site 7 with $V_{s,30}$= 250 m/sec, those according to Table 3.1 of the EC8 belong to the soil of type C and according to the map of seismic hazard of Georgia - to category 3.

The elastic response spectra were calculated at 5 % of critical damping and is accepted that for the seismic intensity 8 the design ground acceleration $a_g = 1.7 m/sec^2$.

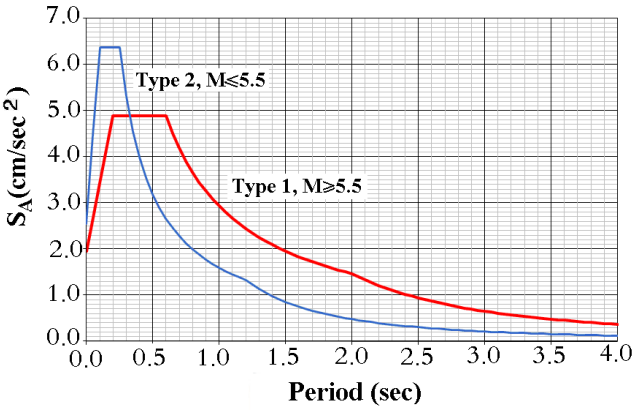

Figure 3.2. Elastic response spectra $(\xi = 5\%)$: ground category III, construction site N 7

IV. STOCHASTIC GROUND MOTION MODEL

The model of seismic ground motion used in this paper is a set of discrete nonstationary Gaussian processes that differ from one another by dominant frequencies, duration and other parameters (Eisenberg 1976). The mentioned feature in the model allows to some extent take into account possible, physically realized diversity of spectral content of various earthquakes and predict spectra of probable earthquakes considering regional seismological data.

Each j element of this set or the ground acceleration $\ddot{U}_o(t,\omega_j)$ in the domain $\omega_{min} \le \omega_j \le \omega_{max}$ is given by the following relation

$$\ddot{U}_{oj}(t,\omega_j) = A(t,\omega_j)\sigma(t,\omega_j)x(t,\omega_j) \qquad (4.1)$$

where ω_j is dominant j-th process frequency, its boundary values ω_{min} and ω_{max} are assumed on the basis of empirical data; $A(t,\omega_j)$ represents a deterministic normalized envelope function; $\sigma(\omega_j)$ is a mean square value of acceleration or denotes random process intensity, that is defined by its variance; $x(t,\omega_j)$ represents a normalized stationary random function with zero mean and unit-variance that is characterized by function of correlation as

$$K(\tau) = e^{\alpha_j|\tau|}(\cos\omega_j\tau + \alpha_j/\omega_j \sin\omega_j|\tau|) \qquad (4.2)$$

where α is correlation coefficient, characterizing bandwidth of the process.

The deterministic normalized envelope function is defined with fixed values ω_j by the following expression:

$$A(t,\omega_j) = \varepsilon_j e t e^{-\varepsilon_j t}, \quad |A|_{max} = 1 \qquad (4.3)$$

where ε denotes the effective duration and process nonstationarity.

Thus, the model expressed by Eqn.4.1 is completely determined with fixed values ω_j using three parameters: α, ε and σ.

The main parameter ω_j of the ground motion model or of the artificial accelerograms has been determined based on data of the Table 2.2 using the expression:

$$\omega_j = 2\pi/T_j \qquad (4.4)$$

The value of the correlation degree characterizing parameter α was evaluated based on analysis of the earthquakes records occurred in Georgia and for the horizontal component consists of $\alpha_j = 0.25\omega_j$ and the vertical component - $\alpha_j = 0.4\omega_j$. The parameter ε_j that defines the amplitude of envelope shape of the simulated time history was determined on the basis of the duration intensive oscillations above-mentioned records at which $\ddot{U}(t) = 0.5\ddot{U}_0^{max}$ and $\varepsilon_j = 0.0148\omega_j$. The value of mean square acceleration σ_j was accepted considering that $3\sigma = A$ and for calculation the value of A was taken from the Table 2.2. Thus calculated parameters are represented in the Table 4.1.

The computer code "GENERACC" was used for the numerical simulation of the artificial accelerograms and then the elastic response spectra were computed. Discrete step of the simulated accelerograms was taken equal to 0.04T. When assessing the probabilistic mean elastic response spectra, the required number of realizations was reduced for each artificial accelerogram up to 25 realizations.

Combined in conformity with Table 4.1, according to a feature of close magnitudes, the mean elastic response spectra were processed using the software "PROCCOD". As a result of this, twelve mean square of the elastic response spectra had been computed, they correspond to the earthquake source zones that are located at a certain distance from the city and characterize dynamics of possible earthquake effect on the given territory.

Table 4.1. Parameters of Artificial Ground Motion Model

Zone No.	R (km)	T (sec)	ω (sec^{-1})	α_h (sec^{-1})	ε (sec^{-1})	σ_h (cm/sec^2)	σ_v (cm/sec^2)
1st group with M=5							
9	17.0	0.14	44.88	11.22	0.664	31.37	21.96
2nd group with M=5.5							
8	31.05	0.20	31.42	7.86	0.465	28.11	19.68
with M=6							
1	22.36	0.22	28.56	7.14	0.423	58.33	40.83
3	18.03	0.21	29.92	7.48	0.443	67.36	47.15
4	10.00	0.18	34.91	8.73	0.517	90.73	63.51
5	22.36	0.22	28.56	7.14	0.423	58.33	40.83
6	8.00	0.17	36.96	9.24	0.547	98.45	68.92
10	10.00	0.18	34.91	8.73	0.517	90.73	63.51
12	14.14	0.19	33.06	8.27	0.489	90.72	63.50
3rd group with M=6.5							
11	18.03	0.24	26.18	6.55	0.387	100.5	70.35
4th group with M=7							
2	33.54	0.34	18.48	4.62	0.273	93.34	65.34
7	33.54	0.34	18.48	4.62	0.273	93.34	65.34

At the final stage of analysis, the effect of the site condition on the obtained probabilistic horizontal elastic response spectra has been evaluated. To assess the influence of local soil conditions were used the experimentally adopted the values of factors S_f for the corresponding construction sites with the average ground properties.

Fig.4.1 shows an example of probable mean elastic response spectrum derived from the source zone 4 and Fig.4.2 displays the effect of local soil condition on the mean elastic response spectrum.

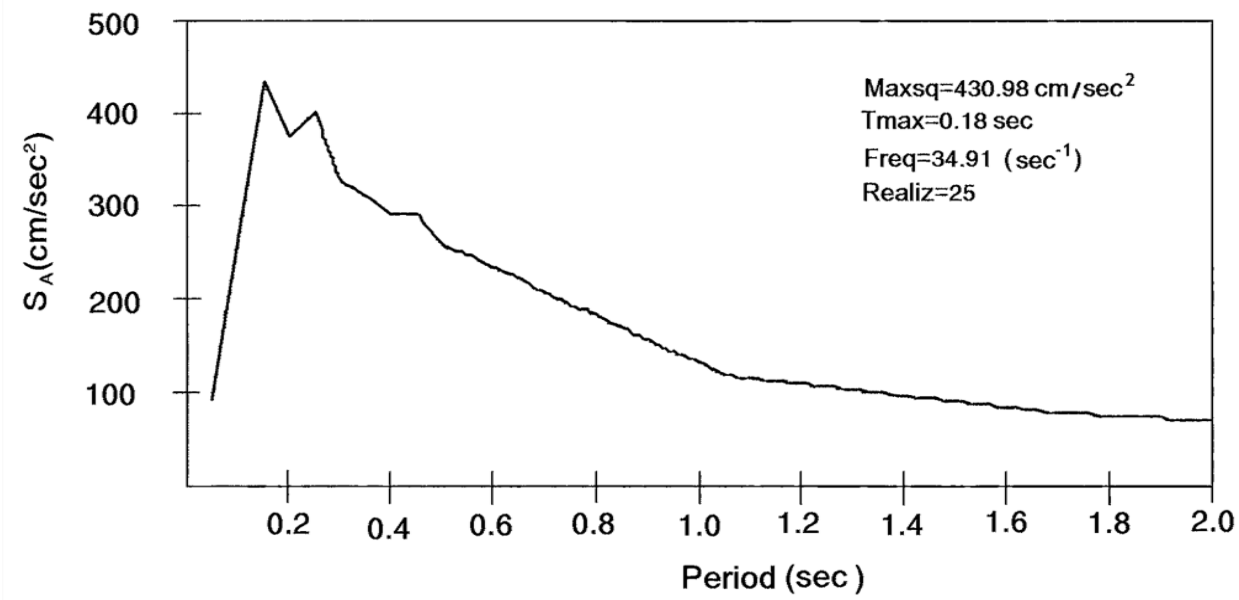

Figure 4.1. Mean elastic response spectrum ($\xi = 5\%$) of simulated accelerogram in case of M=6, R=10 km, for a average soil

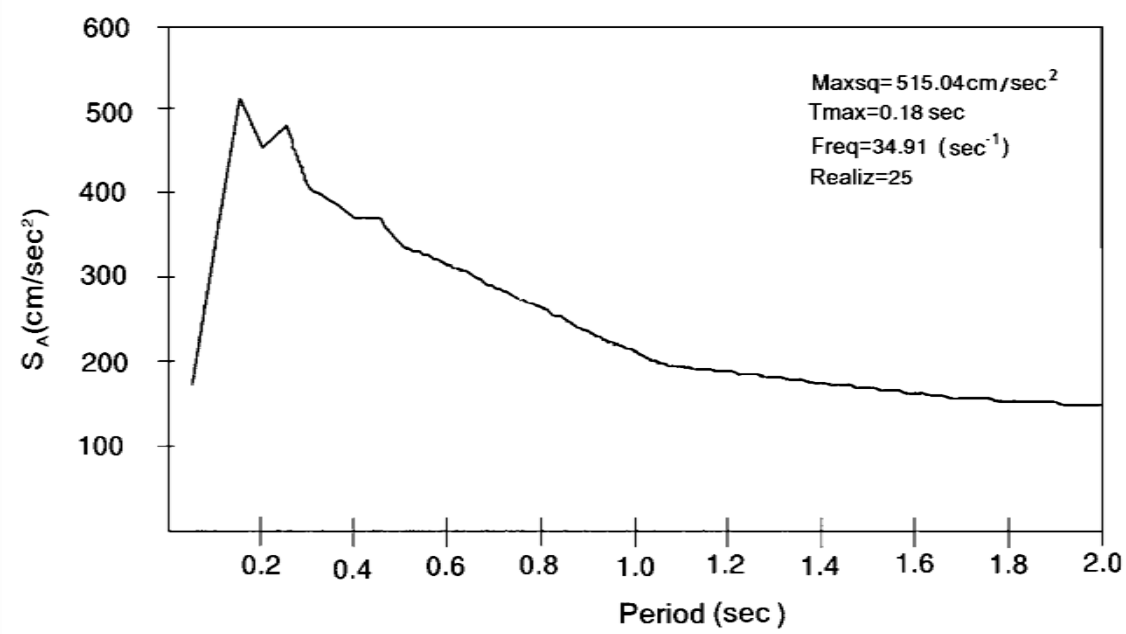

Figure 4.2. Corrected elastic mean response spectrum ($\xi = 5\%$) by the site condition factor S_f =1.195 in case of M=6, R=10 km, for a average soil

V. Conclusions

The improved method of generation artificial accelerograms and of the construction probabilistic elastic response spectra is proposed, which accounts for the location of the earthquake source zones and seismological and geological characteristics of the site.

Based on empirical relations and characteristics of the earthquake source zones the values of dominant period, duration and maximum accelerations of ground motion, expected in the city of Tbilisi has been determined.

On the territory under examination for the concrete construction sites in result of experimental research the dynamic parameters of soil seismological and geological layers are determined and for concrete construction sites

according to the EC8 elastic response spectra are calculated, which can be used in seismic design and analysis of structures.

Based on the nonstationary model of the ground motion for the city of Tbilisi the probabilistic mean elastic response spectra are calculated and their corrected shapes considering the local sites conditions for an average soil are constructed, which can be widely applied in the practice of earthquake engineering in Georgia.

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Applications of Interactive Methods of MOO in Chemical Engineering Problems

A.Mosavi

GJRE Classification - C (FOR) 090403, 090499

***Abstract*-The applications of Multiple Criteria Decision Making (MCDM) in dealing with the chemical engineering optimization problems are rapidly increasing. It has been** inspire**d by increased computational resources and the effectiveness of the methods for solving the Multiple Objective Optimizations (MOO). Meanwhile the number of objectives in MOO of chemical applications, due to the inclusion of the new economical and environmental objectives to the processes, is increasing. As a result, the most recent utilized MOO methods cannot effectively deal with this expansion. However it is important that when selecting a method, the pros and cons set by the method are understood. Otherwise, the optimal results may not deliver the true impression about the problem. In this situation this paper aims to widen the awareness of the readers of the existence of interactive methods, in particular the NIMBUS method, which are capable of handling MOO problems with more than two objectives. For this reason some encouraging experiences and advantages of the NIMBUS method in recent chemical engineering applications are briefly reviewed following a brief introduction to the whole subject.**

Keywords- Interactive Methods, MOO; Chemical Engineering

I. INTRODUCTION

Optimization, in general, is the process of obtaining the value of decision variables, which provides the optimal of requested objectives. The optimization in chemical applications now exists more than the past especially, with the ever changing economic, energy and environmental situations which leads to the better design of chemical systems.

Optimization has wide applications in chemical and its related industries, e.g., mineral processing, petroleum, oil and gas refinery, pharmaceuticals. The study of the chemical engineering applications of optimization in literature, for instance (Tawarmalani and Sahinidis, 2002; Diwekar, 2003; Reklaitis et al., 2006), shows that optimization of the chemical processes has been an interesting field of study for many decades. Moreover up until the 1980s the problems in chemical engineering were optimized utilizing just the single-objective functions. However, real life chemical engineering problems require the simultaneous optimization of several objectives which cannot be solved by single-objective functions. Practical applications of chemical engineering can include many objectives such as cost, profit, selectivity, quality, recovery, conversion, energy required, efficiency, safety, hazard analysis, control performance, environmental quality, economic efficiency, complexity, speed, robustness, etc.

The MOO refers to the simultaneous optimization of multiple, often conflicting objectives, which produces a set of alternative solutions called the Pareto-optimal solutions (Deb, 2001). Many methods are available for solving the MOO problems but the main attention of optimization of chemical processes so far has been single-objective optimization or handling multiple objectives by combining them suitably into one objective. The MOO problems in chemical engineering presented by Seinfeld and MacBride (1970), Shieh and Fan (1980), Umeda et al., (1980) and Grossmann et al., 1982 have been solved by single-objective optimization. Yet, according to (Chankong and Haimes, 1983; Haimes, 1977) by combining the multiple objectives in a single objective function, some optimal solutions might be lost.

Problems containing multiple conflicting objectives are known as multiple criteria decision making (MCDM) problems. In the MCDM, solving the related MOO problem assists the Decision Maker (DM) in finding the right Pareto-optimal solution (Miettinen, 1999). Additionally the solution process needs some involvement of the DM by providing some preferences. Several techniques are available to generate the Pareto-optimal solutions. Extensive researches on the algorithms used for the generating of Pareto-optimal solutions are described in several books and articles (Zeleny, 1982; Cohon, 1978; Steuer, 1986; Clark and Westerberg, 1983, Srinivas and Deb, 1995).

MOO has attracted the researchers in chemical engineering, particularly in the past decade and has received wide attention in the literature and additionally according to Rangaiah (2009) the effectiveness of MOO in chemical engineering problems is increasing by applying the new effective methods.

In the complex chemical processes, finding the optimum operating points of the multiple conflicting objectives given the various economical and environmental constraints is very important for the profitability of chemical plants. For this reason, MOO has been applied to many chemical process optimization problems. In this regard the motivation for this paper is to show that a variety of methods and approaches exists. In this way, people solving different problems are able to use the most appropriate approaches in the given situation. The new generation of chemical engineering problems requires better methods which can handle more than two objectives utilizing the minimum computation efforts.

A. Classification the MOO Methods

Your Examples of surveys of MOO methods are available in Chankong and Haimes (1983), Marler and Arora (2004), Miettinen (1999), Sawaragi et al. (1985), Steuer (1986) and Vincke (1992). However the dimension of existing MOO methods still remains a major challenge because of the conflicting nature of the multiple objectives. On the other hand it is very important that at the time of the selecting a method its pros and cons are understood. Otherwise, the

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optimal results may not deliver the true impression about the problem. In this regard studying the methods would help to give an overview of the existing approaches to chemical process engineers Rangaiah (2009).

The available methods for MOO can be classified in different ways. One way is based on whether the Pareto-optimal solutions are generated or not, and the further role of the DM in solving the MOO problem. This particular classification has been applied by Diwekar (2003), Hwang and Masud (1979), Miettinen (1999), and Rangaiah (2009). Based on this classification method the MOO methods are divided into two main groups: *Generating* methods and *Preference-based* methods. The *Generating* methods generate one or more Pareto-optimal solutions without any inputs from the DM. On the other hand, preference-based methods use the preferences provided by the DM in solving the MOO problem. Figure 1 shows the classification of the MOO methods.

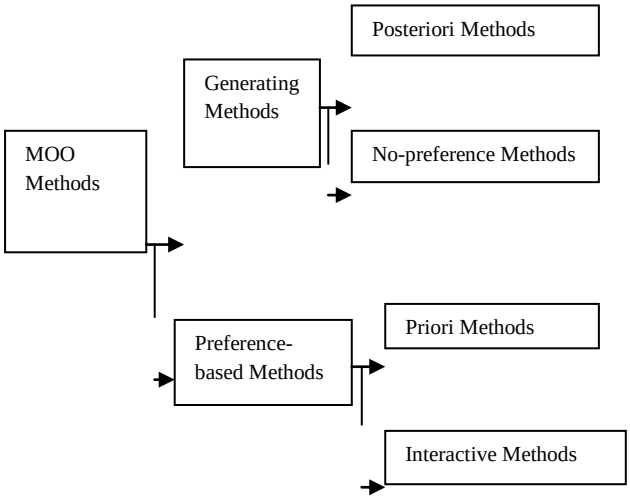

Figure 1. The classification of the MOO methods.

The group of Generating methods is also divided into two groups of No-preference methods and Posteriori methods. If there is no DM involved but the preference information available, it is possible to use No-preference methods which find some neutral compromise solution without any additional preference information. On the other hand in the Posteriori methods, a representative set of Pareto-optimal solutions is generated and then the DM must select the preferred one. In this way, the DM gets an overview of the problem over the visualization on a two-dimension plane involving two objectives. Furthermore, generating the set of Pareto-optimal solutions may be computationally expensive. Evolutionary MOO (EMO) algorithms and GA-based methods belong to this class.

The preference-based methods are also divided into two main groups of the Priori methods and the Interactive methods. In the Priori methods, the DM first gives preference information and then the method looks for a Pareto optimal solution satisfying the objectives.

There are lots of interactive methods available but they are not still widely known among people solving real applications. In interactive approaches, a solution pattern is created and the DM can specify the preference of each interaction. The main specification of this method is its ability to deal with more than three objectives.

From the existed interactive methods, using the interactive approach of NIMBUS (Miettinen, 1999; Miettinen and Makela, 2006) is suggested where the role of a DM is well emphasized and the method is able to satisfy more than two objectives by utilizing minimum computational efforts for the real-life chemical engineering applications which involve more than three objectives.

However, a general MOO method suitable to all type problems does not yet exist, and the results from current methodologies can vary significantly in terms of the achieved Pareto-optimal solutions. For this reason, many standard benchmark test cases such as (Deb, 2001; Kursawe, 1990; Poloni et al., 2000; Silva and Biscaa, 2003; Viennet et al., 1996) have been developed to allow researchers to compare their techniques to others.

II. Review

According to the knowledge of the author of this paper there have been five reviews of the MOO made so far in the area of chemical engineering, including applications in process design and operation, biotechnology and food industry, petroleum refining and petrochemicals, pharmaceuticals polymerization. Bhaskar et al. (2000) presented the background of MOO, different methods and their applications until the year 2000 by reviewing the 30 journal publications covering most of areas in chemical engineering. MOO applications in polymerization are included in the review of genetic algorithm (GA) applications in polymer science and engineering by Kasat et al. (2003). Applications of GA-based MOO optimization in chemical reaction engineering were reviewed by Nandasana et al. (2003). In addition nearly a hundred applications in chemical engineering were studied by researchers and reported in more than 200 journal publications so far which have been thoroughly reviewed by Masuduzzaman and Rangaiah (2008) and Rangaiah (2009).

According to Rangaiah(2009) on average, about 15 new applications of MOO in chemical engineering have been reported every year since 2000. These applications are from several industrial sectors and areas of interest to chemical engineers. Many of them were modeled using first principle models and employed two, to maximum, three objectives. Moreover most of the studies in chemical engineering focused on finding Pareto-optimal solutions and only a few studies considered ranking and selecting one or a few Pareto-optimal solutions for implementation. However more emphasis and studies on ranking and selection from among the Pareto-optimal solutions are expected in the future.

The above mentioned excellent reviews indicate that optimal design of chemical processes e.g., selectivity, productivity and simple profit are mostly used alone in a single-objective for optimization. On the other hand environmental objectives as well as advanced economical objectives are gaining importance due to the increasing emphasis on environmental protection and sustainability, for more proof see chapter two of Rangaiah(2009). As the result of this fact, in the future we are expecting to face more objectives as well as complicated plants, dynamic optimization, and more uncertain parameters.

The above reviews show EMO approaches (which belong to posteriori approaches), in particular GAs, have been most popular for solving the chemical engineering applications mostly in two-objective optimization problems. EMO- based methods have been applied for more than 60% of the reviewed cases. Apart from the above reviews the recently solved chemical engineering problems, for instance Rajesh et al., 2001; Roosen et al., 2003; Subramani et al., 2003; Tarafder et al., 2005; Zhang et al., 2002 which are not included into the five mentioned reviews, also indicate that EMO methods have become very popular, but still only two or maximum three objectives have been considered due to the limitations of EMO approaches to visualize multiple objectives.

By the increasing number of MOO problems in chemical engineering, interactive methods could be utilized as the alternatives to EMO. Moreover the interactive methods complement evolutionary approaches. More details about the relationship of the MCDM and EMO fields are available in Branke et al. (2008).

III. Introduction to Interactive Method

Interactive MOO methods have significant advantages over the methods mentioned above. For instance they overcome weaknesses of the Priori and Posteriori methods as the process avoids setting cognitive overload on the DM, which the comparison of many solutions typically implies. This causes the minimization of computational costs, which is a significant advantage. However, they have been used very rarely in chemical engineering applications which are briefly mentioned in surveys of Andersson (2000) and Bhaskar et al. (2000), and Rangaiah (2009). As Rangaiah (2009) mentions this might be because of the lack of the knowledge about the available methods or the lack of suitable packages. Also a few examples of interactive MOO methods and their applications in chemical engineering are available in Grauer et al. (1984) and, Umeda and Kuriyama (1980).

The statements of interactive methods have been presented in Miettinen (1999); Stewart (1992); Vanderpooten and Vincke (1989); Haimes et al. (1990). In this kind of MOO method, a solution pattern is created and the DM specifies preference information progressively during the solution process. In other words, the solution process is iterative and the phases of preference elicitation and solution generation alternate. In brief, the main steps of a general interactive method according to Miettinen (1999) are the following: (1) initialization, (2) generate Pareto-optimal solutions, (3) ask for preference information from the DM, (4) generate new Pareto-optimal solution according to the preferences (5) If several solutions were generated, ask the DM to select the best solution (6) stop, or if the DM wants to do otherwise, go to step (3). In each interaction some information about the problem or solutions available are collected by DM and then it is supposed to answer some questions in order to provide adequate information. New solutions are generated based on the information specified. In this way, the DM directs the solution process towards such Pareto-optimal solutions that DM is interested in and only those solutions are generated.

The advantage of interactive methods is that the DM can qualify the preferences during the solution process which is a very important state of interactive methods. Actually, finding the final solution is not always the only task but it is also notable that the DM gets to know the problem with its all conditions.

According to the reviewed applications, the interactive MOO methods have been shown to be well-suited for chemical process design problems because it takes the preferences of the DM into account that enables a focused search for the better Pareto-optimal solution, which is the best compromise between the conflicting objectives. For this reason, only those solutions that are of interest to the DM are generated which deliver computational efficiency to the workflow.

Many interactive methods exist e.g., reference point approaches, classification-based methods, satisfying trade-off method, interactive surrogate worth trade-off and the NIMBUS method. However none of them is preferable to the others but some methods may suit some particular types of applications better than others. Methods may differ from each other according to the style of included interactions and the technical matters, the given quality of information to the DM, the specified form of preference information by the DM, the condition of the scalarizing function and generally the Pareto-optimal solutions which are used (Miettinen, 1999).

IV. Nimbus Method

The NIMBUS method of the MOO is available on the WWW-NIMBUS system (Miettinen and Makela, 2000, 2006) and has been operating via the internet at http://nimbus.it.jyu.fi since 1995. It can be used free of charge for teaching and academic purposes, just by applying a browser. All the computation is carried out on the server computer at the University of Jyvaskyla.

Several variants of NIMBUS method exists. But here it is concentrated on the latest online available version, the synchronous version, (Miettinen and Makela, 2006), where several scalarizing functions can be used based on a classification once expressed.

After creating an account it would be possible to save the defined problem as well as the resulted solutions on the system. The WWW-NIMBUS takes the user from one web page to another. The modeled problem can be initialized by filling in a web form. It first asks for the name and the dimensions of the problem. On the second web page, the user can type in the formulas of each objective and constraint function as well as the variables. Later on the interactive nature of NIMBUS method solution process naturally tries to set its own essential condition. The system also has a useful tutorial that guides the user through the different phases of the interactive solution process. In addition, each web page provides individual help as well.

As mentioned earlier by applying the NIMBUS, more than three objective functions can be easily considered only in the presence of more visualization efforts. As long as the comparison and evaluation of the solutions are concerned, the visualizations process is very important as the obtained solutions are presented to the DM via its capabilities. Therefore a good graphical interface tool is necessary in order to enable the interaction between the DM and the method. (Hakanen, 2006).

The modeled MOO problem is initially converted into a scalarized problem using the classified information. Then the solved problem attempts to satisfy the goals which are

defined in the classification. (Miettinen, 1999; Miettinen and Makela, 2006)

Once the DM has classified the objective functions, DM can decide how many Pareto-optimal solutions need to be compared. Then many scalarized problems are solved and the new solutions are shown to the DM. If the DM has found the most preferred solution, the solution process stops. Otherwise, the DM can select a solution as a starting point of a new classification. The DM frequently learns about the possible solutions available for the relevant problem. In other words the DM can learn much more about different solutions satisfying the objectives which best follows the preferences because they take the preference information into account in slightly different ways. (Miettinen and Makela, 2000)

Unlike some other classification based methods, the favorable outcome of the solution processes are not dependent completely on the DM in managing the classification and the appropriate parameter values but partly on the process. This means the classification is a dynamic kind and the DM is free to explore the intermediate points.

V. NIMBUS FOR CHEMICAL ENGINEERING APPLICATIONS

The MOO package of NIMBUS can successfully be applied in chemical process design problems. The researches on the application of NIMBUS in chemical engineering problems such as encouraging experiences related to papermaking and sugar industries have been reported in Hakanen (2006), Hakanen et al. (2004, 2005, 2006, 2007 and 2008) and Rangaiah (2009). These successful cases are described and summarized in Table 1. These studies have focused on offering the chemical engineering community an efficient and practical way of handling all the necessary objectives of the problem. In this regard NIMBUS method has delivered the ability of considering several conflicting objectives that affect the behavior of the problem.

Table 1. Applications of NIMBUS in chemical engineering problems

No	Application	Objectives	Reference(s)
1	Heat recovery system design in a paper mill	Minimization of (1) steam needed in summer, (2) steam needed in winter, (3) area of heat exchangers and (4) cooling/heating needed for the effluent.	Hakanen et al. (2005and 2006) Miettinen et al 2009
2	A co-generation plant to produce shaft power and steam	Minimization of energy loss and total cost while maximizing shaft power.	Hakanen et al. (2006)
3	Glucose-Fructose separation using Simulated Moving Bed and Varicol Processes	Four objectives: (1) maximization of throughput, (2) minimization of solvent consumption indesorbent stream, (3) maximizing product purity, and (4) maximizing recovery of valuable component in the product stream.	Hakanen et al. (2007)
4	Water Allocation Problem	Three objectives : the goal is to minimize the amount of fresh water taken into the process and also to minimize the amount of dissolved organic material in critical parts of the process by determining the right recycling of water	Hakanen et al. (2007), Miettinen et al (2009)
5	Simulated Moving Bed Processes	Four objectives: (1)functions represented throughput, (2) consumption of desorbent, (3) purity and (4) recovery	Miettinen et al (2009

The solution of the *Simulated Moving Bed* design problem described in Hakanen *et al*. (2007) and Miettinen et al (2009), including four highly conflicting objective functions, is a novel approach. However, previously only two or maximum three objective functions could be considered (Subramani et al., 2002 Zhang, Z., 2003). This enabled full utilization of the properties of the problem without any unnecessary simplifications. In addition, the DM via NIMBUS gained more understanding of the considered objectives' interactions and therefore learned more about the problem.

The solution for the *Water Allocation* problem, as it is represented in Hakanen *et al*. (2007) and Miettinen et al (2009) is a MOO problem by nature. The other available approaches can produce only one solution at a time corresponding to the upper bounds set for the new inequality constraints. It is also difficult to set correct upper bounds to find the most desirable solution without knowing the behavior of the problem and the roles of the objective functions and the constraints. In this condition according to the preferences of the DM and the study of the interrelationships of the different objective functions by utilizing the NIMBUS design tool, different solutions can be generated. The NIMBUS in Hakanen *et al*. (2007) and Miettinen et al (2009) first of all provided a better understanding of the interrelationships of the objective functions when compared to the previous solutions and secondly dealt with more objectives utilizing less computational recourses.

In the other application, *heat recovery system design*, there are four objective functions involved. Solving it doesn't cause any troubles for an interactive method like NIMBUS. In a detailed description of the interactive solution process presented by Hakanen et al. (2005, 2006) a new insight into the problem obtained and a satisfactory solution found.

VI. Conclusion

The interactive methods, in particular NIMBUS, for reason of solving the MOO problems of the MCDM in chemical engineering applications have introduced and following it the advantages of applying the NIMBUS in such applications were discussed.

Interactive approaches in general allow the DM to learn about the problem considered and the interrelationships in it. As the result, deeper understanding of the phenomena in question is achieved. Because the DM can manage the search for the most preferred solution, only interesting solutions are generated which means savings in computation time which is a significant advantage. For taking the true nature of the problem into account specially by including the environmental and economical objectives into the process the interactive methods can easily be applied.

However, when the problem has more than two objectives, the visualization is no longer simple. In this situation the interactive approaches offer a viable alternative to solve the problem without artificial simplifications.

Because interactive methods rely heavily on the preference information specified by the DM, it is important to select such a user-friendly method, NIMBUS, where the style of specifying preferences is convenient for the DM. The presented applications have shown how interactive MOO can be utilized in chemical process design by demonstrating of their benefits. In all the cases, it was possible to solve the problems in their true multi-objective character and an efficient tool was created to support the DM in the decision making problem.

VII. References

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Performance Assessment of a Solar Water Heater for Process Water Purification in Food Processing Industries

GJRE Classification - J (FOR)
090508 , 090805, 091505, 090703

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***Abstract*- Solar water heater earlier designed and fabricated in the National Center for Energy Research and Development NCERD, was used to carry out a comparative study on the efficiency of the solar heating system in purifying process water used in food industries. Hence, samples of water from a local stream (Ajiye Spring in Odenigbo area, Nsukka, Enugu State) and bottled water were used for this study. Fresh water heated in the solar water heater which attained temperatures >830C were allowed to cool overnight. Some physicochemical parameters depicting water quality such as pH, total solid, acidity, alkalinity, chlorine content, lead content, hardness of water, dissolved oxygen, dissolved carbon dioxide and coliforms were analyzed before and after heating. Results obtained show that in addition to hot water production, the designed and fabricated solar water heater improved the water quality by reducing the values of the water quality parameters within the acceptable U.S Environmental Protection Agency Quality Standards for drinking water. In some cases, some of the quality indices appear far better than those of portable water.**

Keywords-Water purification, solar water heater, environmental Protection Agency, styro foam and ultra violent radiation.

I. INTRODUCTION

Water is found on earth in all three forms. It covers about two-thirds of the surface of earth. However availability of portable water has remained elusive to man. Worldwide, unsafe water is a major health problem being the root cause of many diseases, especially in developing countries. An estimated 1 billion people do not have access to safe water. The World Health Organization (WHO) estimates that diarrheal diseases that result from contaminated water kill about 2 million children and cause about 900 million episodes of illness each year (World Bank 1992). As a result, several ways of purifying water have been developed. Most of these methods are expensive and require technical- know- how to build, operate and maintain. One effective method of purifying water is by use of sunshine. The solar disinfection SODIS (Solar Disinfection of water) system developed by scientists at the Swiss Federal Agency for Environmental Science and Technology (EAWAG) recommends placing PET bottles (usually discarded mineral water /beverage bottles) painted black on

Water plays many critical roles in food processing operations such as in blanching, washing, boiling, cooking filtration etc. Solvent such as salts and sugars found in water affect the physical properties of water. The boiling and freezing points of water is affected by solutes. For instance, one mole of sucrose (sugar) raises the boiling point of water by 0.52oC and one mole of salt raises the boiling point of water by 1.04oC while lowering the freezing point in similar way (Vaclacik et al, 2003). Solutes in water lowers water activity (the rate of the vapour pressure of water in a solution to the vapour pressure of pure water) which also affects many chemical reactions and the growth of microbes in food (Wikipedia, 2008), and which in turn affects the safety of food, preservation and shelf-life By and large, water used for food processing operations should be bacteriologically acceptable.

Water for food processing is expected to meet the quality standards for drinking water (Vevrek, 2002). Thus, any treatment given to water is supposed to purify it, making it safe for drinking, food processing and other industrial uses.

The U.S Environmental Protection Agency (U.S EPA) has established water quality standards for drinking water. These are enforceable standards called "maximum contaminant levels" or "MCLs" which are established to protect contaminated water that present a risk to human health. An MCL is the maximum allowable amount of a contaminant in drinking water which is delivered to the consumer (U.S EPA, 2007). Table 1 below shows the various standards for drinking water from different sources

Table 1 : National industrial standards and Britain pharmacopoeia (BP) 2007 version (May & Baker)

TEST	SPECIFICATION	
Characteristics clear, colourless	Tasteless and odourless liquid	
pH	6.5 – 8.5	@28^{o}C = 6.9-7.5
Total Hardness as $CaCO_3$	≤ 100mg/L	≤ 50mg/L
Conductivity	≤ 100 Um^{-1}	≤ 499$USCM^{-1}$
Total dissolved solid	≤ 500mg/L	At 28^{o}C = 500mg/L
Sulphate	100mg/L	≤ 20mg/L
Free residual chlorine	01mg/L	0.1mg/L
Chloride	100mg/L	≤ 20mg/L
Iron estimation	0.03mg/L	≤ 0.03mg/L

Source: May and Beaker (2007)

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Table 2 : U.S Environmental protection agency quality standards for drinking water

Parameter	Maximum Contaminant level (MCL/Expected limit)
pH	6.5-8.5
Total solids	500mg/L
Hardness	100mg/L
Turbidity	4 NTU
Acidity	100mg.L
Alkalinity	100mg/L
Dissolved carbon dioxide	50mg/L
Dissolved oxygen	50mg/L
Copper content	1.0mg/L
Lead content	0.01mg/L
Iron content	1.0mg/L
Chlorine content	250mg/L
Coliforn count	Icfu/100mL
Taste	Unobjectable
Odour	Unobjectable
Colour	Unobjectable

Source: US EPA, 2007

Approximately 1.55 x 10^{18} kwh of solar energy reach the earth's outer atmosphere each year. Of this energy, about 35% is reflected back into space, the atmosphere absorbs 18% and 47% reaches the earth's surface (Garba et al, 1999). Given its inexhaustibility, environmental friendliness and general availability, solar energy is a form of renewable energy considered to be of greater attraction to developing nations like Nigeria (Mika' Ilu et al, 1990).

Nigeria lies between latitudes 3^{o}C and 14^{o}C North of the equator and between longitudes 3^{o}C and 14^{o}C east of the Greenwich meridian. Owing to this geographical location she receives abundant daily sunshine and has ambient temperature ranging from about 27^{o}C to 36^{o}C. Average daily insolation of about 5.8kwh/m^{2}/day is received in the South and about 7.5kwh/m$^{2/}$day in the north (Osuji, 2003). It is estimated that Nigeria receives on her land area of 923, 769 square kilometers an annual insolation that is 4000 times the annual production of crude oil in energy terms (Ezeilo, 1978). With the level of advancement, in the science and technology of solar energy in Nigeria, there is no doubt that the energy requirements of the populace in the area of hot water production, water pumping, water distillation and purification, etc, can be met by this viable alternative.

II. Materials and Methods

The solar water heater used in this study was designed and fabricated at the National Centre Fore Energy Research and Development, University of Nigeria, Nsukka. It consists of an absorber plate made of mild steel sheet, solar collector, made of transparent sheet of glass, water storage tanks and the stand. The absorber plate was made of mild steel which is a very good conductor of heat. It is malleable and relatively cheap. Copper tube was used to form a loop on the mild steel absorber. Water in the loop is heated by the radiant energy trapped by the absorber. The choice of copper for the tube was informed by its excellent heat conducting properties. It is very malleable, ductile and resistant to corrosion. Both the tubes and mild steel sheet which make up the absorber plate were painted black to increase absorbance and retention of absorbed heat. Glass wools were used to insulate the space between the hot water tank and its outer jacket to minimize heat losses from the water tank while styro-foam was used to insulate the flexible hoses. The two storage tanks for hot and cold water respectively were 105cm apart and constructed with 40 cm thick galvanized iron to prevent corrosion. The whole set up was erected on steel support as shown in figures 1,2 and 3 below. The system is single- glazed and the device tilted to an angle of 22.15^{o} to ensure that maximum irradiation falls on the solar collector. Nsukka is located at latitude 7.15^{o} and according to Bill (1983) solar collectors are best mounted facing southwards and tilted at an angle given by the summation of the latitude of the area and additional 15$^{o.}$ Thus, for Nsukka, the site of this work, the optimum angle of Inclination for the solar collector = Latitude +15o

= 7.15o + 15o = 22.15o

Raw untreated water from a local river source was introduced into the cold water tank positioned at the top of the device via a funnel, (Fig. 3.) The water immediately flows through a flexible hose into the copper tubes of the absorber plate in the casing. Solar radiation striking the surface of the transparent glass penetrates and heats up the water in the tube, thus purifying it. The purified water can then be collected through a pump which is incorporated to the hot water tank. The device is mounted in an area where there are no trees or shade of any sort so as to maximize the solar radiation striking the solar collector. The solar water heater fabricated was used to heat water and some water quality parameters were measured to assess the efficacy of the system in the production of heat and purification of raw water. The amount of insolation at any given time was determined with a solar radiation sensor (sensol monokristallin) while the temperature of the fresh and heated water was measured with a mercury in glass thermometer (0-100oC).

Raw water sample used for this work was collected from Ajiye Spring in Odenigbo area, Nsukka Enugu State while the bottled portable water for the control was purchased from a reputable water bottling company in Nsukka town. Analysis was carried out on the raw water sample and heated water from the solar water heater (which attained temperatures >83oC and allowed to cool overnight).

The methods described by Franson (1976) were used in the determination of the physicochemical characteristics of water including pH, total solid, acidity, alkalinity, Iron, copper and lead content, dissolved oxygen, dissolved carbon dioxide and coliforms. Chlorine and water hardness were however determined by AOAC, 1990 standard methods

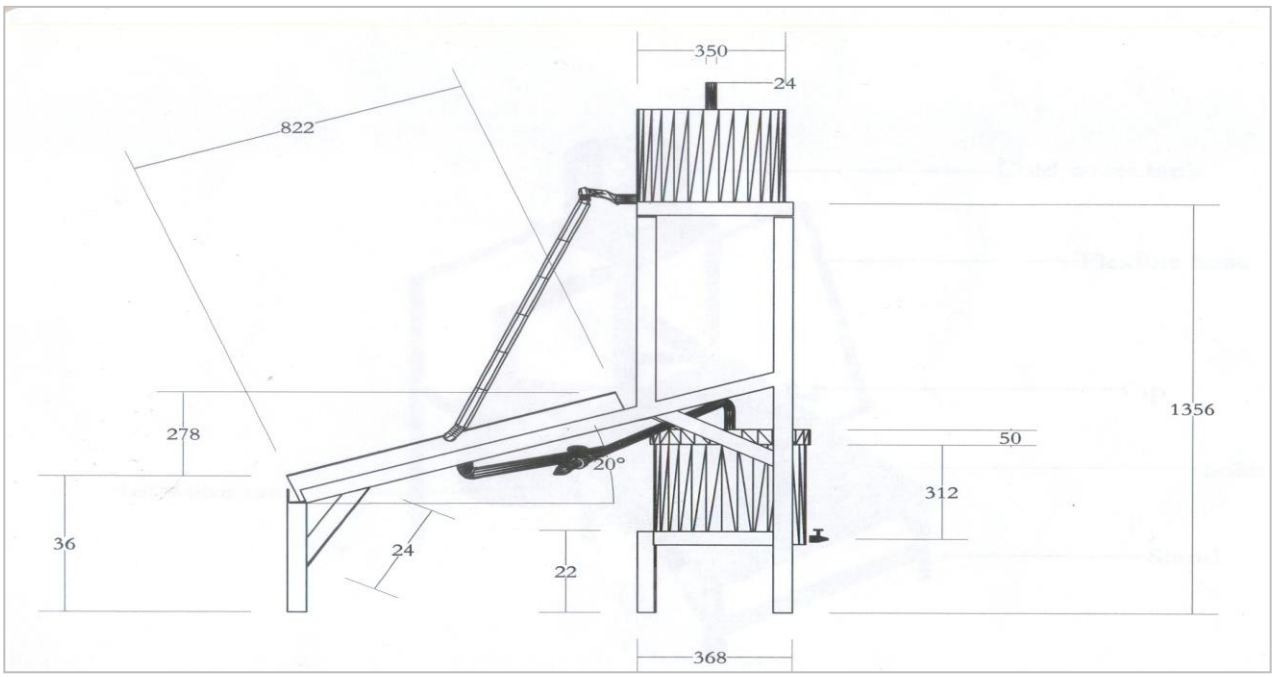

Fig 1: Side View of the Solar Water Heater (in mm)

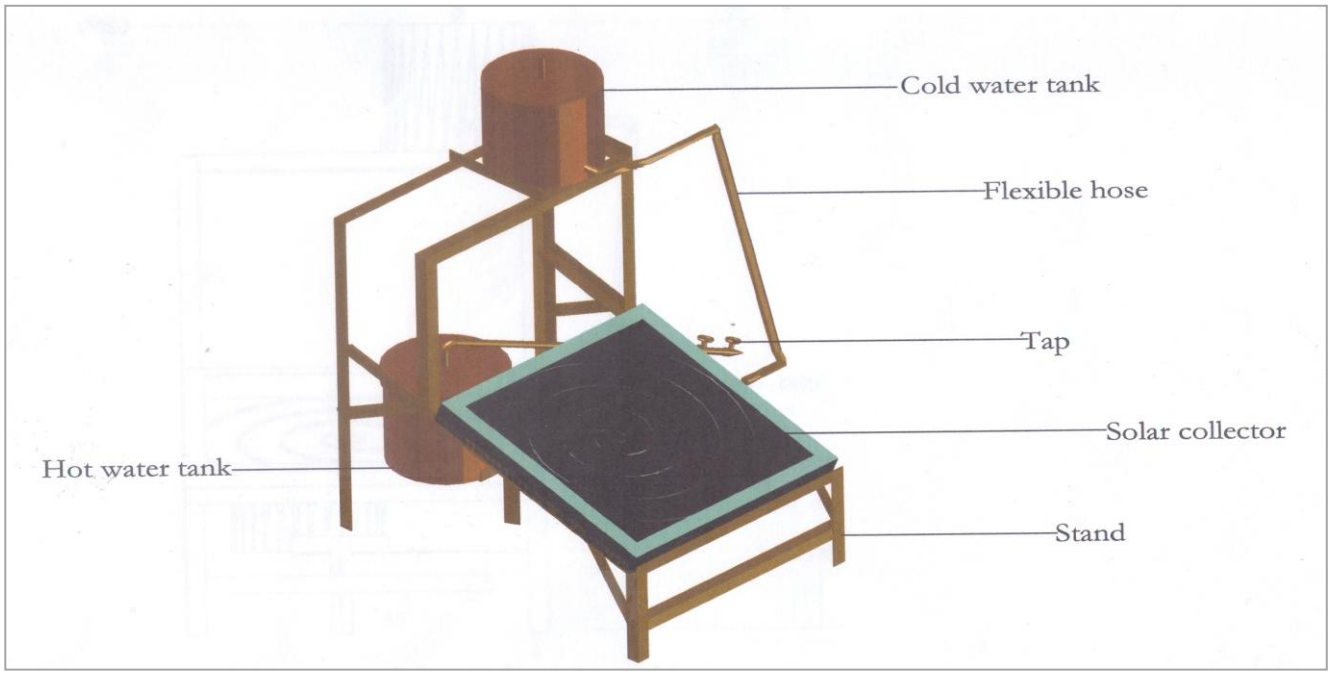

Fig 2: Solid Isometric View of the Solar Water Heater

Fig 3: The Fabricated Solar Water Heater

III. Results and Discussion

The results of the environmental parameters of the experimental site are presented in Table 1. The maximum and minimum temperatures attained in the solar water heater during the experimental period are 83^{o}C and 31^{o}C during hot and cloudy days respectively. These temperatures correspond with the hours of highest and lowest solar radiations of 827.425 w/m^2 of 21 March, 2009 and 164.8w/m^2 of 20 March, 2009 respectively. It was observed that the temperature of the water directly depends on the amount of solar radiation received by the solar water heater. This implies that at a particular time, if the solar radiation is high, automatically the temperature of the water increases and if the solar radiation is low, the temperature of the water decreases. The relative humidity of the experimental environment varied with time and day; therefore, there is no defined relationship between relative humidity and other parameters measured during the period. From the results obtained (Table 4), the solar-heated water was more acidic than the portable water
used as the control, though the pH value was within the US. EPA's standard (6.5 – 8.5). This is attributed to the dissolved CO_2 in water that react with water to form carbonic acid (trioxocarbonate (iv) acid which in turn, dissociates when heated in the solar water heater to water and carbon (iv) oxide (Ababio, 1977). The total solids decreased when impure water was subjected to solar radiation. This is because when water is heated, the solids in it are disintegrated and settle out, thereby making the water lighter (U.S. EPA, 2007). This view holds equally for the turbidity of the solar treated water. Result obtained show that the total solid content and turbidity of the solar heated water was below the maximum contaminant level for U.S EPA's standard water. While the acidity decreased, alkalinity increased in the solar heated water. The increased alkalinity is obviously due to the increasing pH of the water (towards alkaline). The two parameters met the internationally accepted standards. From the results, it is observed that water hardness decreased as its temperature increased. This is because the dissolved calcium hydrogen trioxocarbonate(iv), $Ca(HCO_3)_2$ which causes hardness, decomposes on heating. The calcium trioxocarbonate(iv),$CaCo_3$ formed is insoluble and this brings the calcium ions which are responsible for water hardness out of the solution as a precipitate (Ababio, 1997). The iron content of the water reduced significantly in the solar- heated water sample, while the chlorine ions may have formed salts with iron ions. The iron (III) chloride salt formed is soluble in water and could be recovered if needed by evaporation to dryness or crystallization. It was also observed that there is 100% elimination of choliforms in solar- heated water sample. This is most probably attributed to the high temperatures recorded during the study. Finally, results of the sensory evaluation of the water samples show that the colour, odour, taste and general acceptability of the solar water sample compared favourably with the portable water sample From the result, Table the solar water sample was generally rated the best; its mean ±standard deviation being the highest (Table 5), the mean sensory scores of the panelists being "Extremely unobjectionable".

Table 1: The Environmental Conditions of the Experimental Site

17 – 03 – 09

Time (Hr)	solar rad 1^o (w/m^2)	Ambient temp. T^o (^oC)	Relative humidity RH (%)	Heated water Temp. t^o (^oC)
0900	378.60	23	70.78	34
1100	484.69	28	56.06	56
1300	640.91	33	43.63	75
1500	608.53	31	37.10	69
1700	303.25	30	34.64	54

18 – 03 – 09

Time(Hr)	solar rad. 1^o (w/m^2)	Ambient temp. T^O (^OC)	Relative humidity RH (%)	Heated water Temp. t^o (^oC)
0900	282	22	74.39	33
1100	459.42	28	62.07	54
1300	483.59	29	53.61	63
1500	488.25	29	44.98	77
1700	331.68	27	39.17	52

19 – 03 – 09

Time (Hr)	solar rad. 1^o (w/m^2)	Ambient temp. T^O (^OC)	Relative humidity RH (%)	Heated water Temp t^o (^oC)
0900	256.60	23	77.96	31
1100	391.15	27	63.37	45
1300	631.59	28	49.71	79
1500	514.73	28	44.98	70
1700	351.15	29	43.49	58

20 – 03 – 09

Time (Hr)	solar rad 1^o (w/m^2)	Ambient temp. T^O (^OC)	Relative humidity RH (%)	Heated water Temp. t^o (^oC
0900	164.8	22	78.06	33
1100	214.28	24	71.16	59
1300	450.09	28	60.13	65
1500	357.23	28	48.94	58
1700	221.28	21	58.59	45

21 – 03 – 09

Time (Hr)	solar rad. 1^o (w/m^2)	Ambient temp. T^O (^OC)	Relative humidity RH (%)	Heated water Temp. t^o (^oC
0900	193.8	23	71.1	33
1100	503.32	28	56.04	65
1300	827.425	32	39.59	83
1500	615.66	30	31.31	76
1700	334.61	28	38.17	46

Table2: Quality indices of the Treated and Untreated water

Parameters	Fresh untreated water	SolarSolar treated water	Portable water	USEPA's standard
pH	6.2	6.1	6.9	6.50-8.50
Total solids (mg/l)	594	182	61	500
Acidity	54	35	15	100
Alkalinity (mg/l)	64	82	20	100
Dissolved Carbon dioxide (mg/l)	96	30	24	50
Dissolved oxygen (mg/l)	16	3.2	7	50
Total Hardness (mg/l)	27.2	3.2	20.4	100
Chlorine (mg/l)	6.07	0	12.14	250
Coliform Count (cfu/ml)	5.5	0	10	10

Copper (mg/l)	0	0	0	10
Iron (mg/l)	0.24	0	0.24	1
Lead (mg/l)	0	0	0	0.01
Iron (mg/l)	0.23	0	0	1.0
Chlorine(mg/l)	184.3	34.03	22.1	250
Coliform (cfu/ml)	5	0	0	1

Table 3: Sensory Evaluation Results

Parameters	**Solar water heater	**portable water	**Raw water
Color	^{a}6.95 ±0.2236	^{b}6.74 ±5.215	^{c}6.537 ±0.351
Odour	^{a}6.75 ±0.443	^{b}5.85 ±5.480	^{c}5.35 ±4.95
Taste	^{a}6.70 ±0.4894	^{b}6.44 ±4.36	^{c}6.61 ±0.452
Overall acceptability	^{a}6.65 ±0.4894	^{b}6438 ±0.327	^{c}5.65 ±0.753

*Values carrying different superscripts in the same row are significantly different (P<0.5)
**Values are mean ± standard deviation

Conclusion and recommendation

The solar water heater designed and fabricated was able to generate enough heat for the purification of raw water for industrial applications. Data generated from the water quality indices that were measured in the course of this research compared closely and effectively with those of the US-EPA standards. Though the device could not retain its heat up to 90% at night, it is hoped that with a better insulating material, a more efficient solar water heater that may not incur more than 3% heat loss at night, may be achieved.

IV. Acknowledgement

The authors appreciate the assistance from the Department of Food Science and Technology, University of Nigeria, Nsukka for the use of its laboratory facilities.

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Current Philosophy for Progressive Collapse Resistant Design

GJRE Classification - E (FOR) 090502,090501

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***Abstract*-Although progressive collapse of structures is a relatively rare event, its consequences could be catastrophic in terms of life and/or property loss. In the past decade, the number of publications on progressive collapse and related topics has risen significantly. The consensus of the engineering community is justifiably to focus on life safety and collapse prevention rather than other performance measures. This paper explores the most important trends on analysis and design of new structures to mitigate the effects of progressive collapse.**

I. Introduction

Many building codes and design standards include provisions that are intended to minimize the potential for progressive collapse or mitigate its consequences in case it occurs. One of the standards that are dedicated for design of buildings to resist progressive collapse is published and updated periodically by the United States Department of event is difficult to quantify. The two commonly used progressive collapse mitigation approaches discussed below are independent of the hazard source [7].

Direct Design Approaches.

Direct Design method seeks to strength the structure explicitly to resist progressive collapse. Two methods are commonly use; 1) the Alternate Path (AP) method where the structure is designed to bridge over a notionally removed structural element, and 2) the Enhanced Local Resistance (ELR) method, in which essential primary load carrying members are strengthened to resist a specific load magnitude

Indirect Design Approaches.

The indirect design methods provide resistance to progressive collapse implicitly by improving structural and integrity and providing various levels of strength, continuity Defense (DoD) [1]. This publication, which is part of the Unified Facilities Criteria (UFC), provides analysis and design provisions and recommends measures to reduce the potential for progressive collapse or mitigate its effect if it occurs. Although UFC series were developed for U.S. DoD facilities, it is made available for other code writing bodies to adopt it in whole or in part. This application, referred to in this paper as the UFC, applies to buildings consisting of three stories or more. The purpose of this paper is to present recent developments in progressive collapse resistant design as highlighted in the recent UFC provisions [1].

A. Design Approaches

The causes of progressive collapse are numerous including human deliberate actions, faulty design/construction, and vehicular impact. Therefore, initial force generation the ductility". These goals are achieved through; 1) proper plan layout, 2) providing a system of ties, 3) using load-bearing interior partitions, 4) proper detailing to enhance catenary action of the floor slab, 5) ductile detailing.

UFC does not preclude the use of any of ASCE 7 Indirect Design Approaches [7] listed above but emphasizes the use of Tie Forces (TF) to enhance continuity, ductility, and structural redundancy. Structural ties used to tie the structure in all directions are designed for prescribed minimum tensile forces. The current UFC recommends a combination of direct and indirect approaches for progressive collapse design of buildings based on the Occupancy Category (OC). Table 1 shows the OC with the corresponding progressive collapse prevention measures

Occupancy Category	Progressive Collapse Design Requirement
I low hazard buildings such as agricultural and storage facilities)	No specific requirements
II buildings other I, III, and IV	Option 1: Tie Forces for the entire structure and ELR for the corner and penultimate columns or walls at the first story. Option 2: AP analysis for specified column and wall removal locations.
III Schools, some healthcare facilities, water treatment facilities, etc.	AP analysis for specified column and wall removal locations; ELR for all perimeter first story columns or walls.
IV Essential healthcare facilities, police and fire stations, etc.	Tie Forces; Alternate Path for specified column and wall removal locations; ELR for all perimeter first and second story columns or walls.

Table 1: Occupancy Categories and the corresponding progressive collapse resistant design measures.

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For critical structures in OC II and higher, UFC requires ELR for corner columns beside other measures as shown Table 1. This is consistent with recent research arguing that loss of corner columns cannot be compensated for by other measures such as tying the structure [2, 4]. For OC IV, all available options are used to mitigate the consequences or progressive collapse including AP for specified column and wall removal, ELR for perimeter columns in first and second stories, in addition to tying the structure in perpendicular directions.

Equivalent Local Resistance

For OC II and III, ELR requires increasing the shear capacity of column and its connection to other structural elements to exceed the flexural capacity. For OC IV, the flexural capacity must be 2 times the baseline column and shear capacity should exceed the flexural capacity in the first two stories. Therefore, the current ELR approach seeks to ensure that brittle shear failure does not occur prior to flexural failure in columns or its connections to horizontal structural elements

Alternate Path Analysis

AP investigation seeks to ensure that the structure has the ability to bridge over designated notionally removed columns. Demand due to removal of column is obtained from permitted analysis methods including 1) Linear Static (LS) Procedures, 2) Nonlinear Static (NS) Procedures, or 3) Nonlinear Dynamic (ND) Procedures.

Horizontal and Vertical Ties

For OC II and IV the structure must be tied mechanical in the horizontal plane as well as the vertical plane. In the horizontal plane, each floor must be provided with longitudinal, transverse, and perimeter ties. The floors need not be reinforced with additional ties if the beams and girders in the floor can resist the empirically prescribed tie forces while undergoing 11.3 degrees. Columns must be tied mechanically along their vertical axes. The prescribed tie forces are independent of the design gravity forces. Tie forces calculated based on gravity forces given in Equation 1.

$$w_F = 1.2D + 0.5L$$

Where, w_F = floor load (kN/m2)
D = Dead load (kN/m2)
L = Live load (kN/m2)

(1)

For flat slab structures, there are no beams to transmit tie forces; therefore, the floor system must be reinforced with orthogonal mechanical ties. The required tie strength in either direction is given by Equation 2.

Fi = 3 wf L1

(2)

Where, wf = floor load (kN/m2)
L1 = Greater of the distances between the centers of columns, frames or walls supporting any two adjacent floor spaces in the direction under consideration (m)

II. The Alternate Path Method

The AP method remains the common denominator in most codes and standards including UFC. The methods require the structural system to have the ability to bridge over a notionally removed column. This ability is measured by satisfying the traditional Load and Resistance Factor (LRFD) Equation 3.

$$\emptyset R_n \geq \sum \gamma_i Q_i$$

Where, $\emptyset R_n$ = Design strength (3)
$\emptyset$ = Strength reduction factor
R_n = Nominal strength which may include over-strength factor.
$\sum \gamma_i Q_i$ = Required strength
γ_i = Load factor
Q_i = Load Effect

A. Assessment of Component Strength

Progressive collapse induced forces are different from seismic forces. Seismic forces are lateral and assessed with reasonable degree of reliability while progressive collapse is gravity driven with difficulty in quantifying the triggering event. However, structural response and component actions are very similar. Therefore, UFC adopted many of the seismic provisions in FEMA 356 [3]. UFC requires each component action to be classified as force-controlled or deformation-controlled. Table 2 shows the classification of actions for certain structural components in moment-resisting frames.

Moment Frame Component	Deformation-Controlled Action	Force-Controlled Action
Beams	Moment (M)	Shear (V)
Columns	M	Axial load (P), V
Joints	--	V

Table 2: Classification of component action for moment resisting

Once a component action is classified as deformation-controlled or force-controlled, the component capacity must be calculated. For deformation-controlled actions, the capacity is calculated using the expected value of the applicable material strength such as yield strength or ultimate strength. For force-controlled actions, the capacity is calculated using the lower-bound material strength defined as the expected value minus one standard deviation. UFC adopted ASCE 41 [3] for calculating component action capacity

When AP analysis is conducted using LS methods, the action capacities are forces, moments, etc.

When AP analysis is conducted using NS or ND methods, the action capacity for force-controlled actions is force or bending moment calculated using lower bound material strength. However, the action capacity for deformation-controlled actions is prescribed limiting deformation.

B. Calculation of Component Action Demands for the Alternate Path Method

Component action demand whether force-controlled or deformation-controlled is calculated by placing maximum loads at the bays adjacent to notionally removed columns and minimum gravity loads further from notionally removed columns as shown in Figure 1. LS procedures only approximate structural response during progressive collapse; however, they remain more popular amongst structural engineers compared to NS and ND procedures. For NS procedures, Equation 4 shows the gravity load combination to be placed on panels above the notionally removed column for the purpose of calculating the deformation -controlled component action

$G_{LD} = \Omega_{LD}$ [(0.9 or 1.2) D + (0.5L or 0.2 S)] (4)

Where, G_{LD} = Increased gravity loads for deformation-controlled actions for linear static analysis.

Ω_{LD} = Load increase factor for calculating deformation-controlled actions for linear static analysis.

D = Dead load including facade loads (Ib/ft^2 or kN/m^2).

L = Live load include live load reduction per ASCE 7 (Ib/ft^2 or kN/m^2).

S = Snow load (Ib/ft^2 or kN/m^2).

Equation 5 shows the gravity load combination on bays away from notionally removed column.

G =(0.9 or 1.2) D + (0.5L or 0.2 S) (5)

The multiplier Ω_{LD} which is typically greater than 2.0 is included in Equation 4 and not in Equation 5 because it is intended to account for dynamic in the vicinity of notionally removed columns

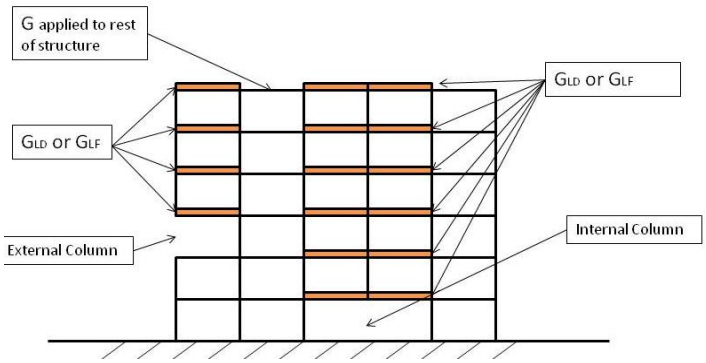

Figure 1: UFC recommended locations for gravity loads on bays above notionally removed column and away from it.

Load combinations for force-controlled action used with LS procedures are detailed in UFC [1] and are very similar to Equations 4 and 5 in this paper except the dynamic effects multiplier ΩLF is calculated differently. Similarly, gravity load combinations for NS and ND procedures are described in UFC but placed according to Figure 1.

III. Discussion

- Current progressive collapse philosophy assumes the cause of the event is unknown and seeks to assess the response of the structure independent of the causative event that led to loss of primary load carrying members. Therefore, extreme load events such as blast are not directly addressed by most progressive collapse resistant design codes and standards. Instead, blast and direct weapon effects are treated separately in different standards. However, some studies indicate that structures strengthened against seismic forces are likely to perform better if the structure is subjected to blast loads [6]. One
- reason is that the ductile seismic detailing is essential to develop the favorable catenary action that provides ample warning before incipient formation of a collapse mechanism [5]. Typical causes that are implicitly addressed by progressive collapse standards such as UFC include faulty design, construction errors, limited vehicle impact, small scale gas explosions near columns, etc.
- Current design standards are beginning to benefit from the wealth of research knowledge obtained from seismic earthquake engineering. Analysis methods, material responses, and design approaches for progressive collapse can reuse this seismic engineering knowledge while realizing the differences in the nature and direction of load application between seismic forces and those associated with progressive collapse. The current UFC standard clearly adopts many of seismic rehabilitation research knowledge incorporated in FEMA 356 or ASCE 41 [3].
- For Occupancy Categories where the human loss consequence of progressive collapse are serious, a multi-faceted approach to collapse mitigation is essential. It is difficult to transfer loads from lost perimeter columns –especially at corners, to adjacent supports. Therefore, Enhanced Local Resistance is a reasonable choice. For interior columns, either Enhanced Local Resistance or bridging over lost column based on the Alternate Path method should be considered. It is also important to tie the structure mechanically as recommended by UFC in both horizontal planes and vertical column lines. Horizontal ties at floor slab levels will contribute to the necessary ductility needed for catenary action to develop. The recommended overall ductile behavior is essential for progressive collapse design as well as traditional strength methods or Load and Resistance Factor Design methods.

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The Current Construction Project Extranet Practices in the Construction Industry

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GJRE Classification - E (FOR) 090505, 090599

***Abstract*-Construction Project Extranet (CPE) is a state-of-the-art business integration tool, which includes all the functions of project management for the enterprise and its partners. CPE applications include requests for information, document management, contracts management, cost management and e-Procurement. This paper reports based on the findings obtained from the authors' questionnaire survey conducted between July 2002 and October 2002, with contributions received from 173 organisations representing UK construction companies, architects, Information Technology (IT) consultants and clients. It is also discuss the development of CPE between 2003 and 2009. According to 11 research results revealed increasingly enthusiasm in construction for the widespread use of CPE. Moreover there are some barriers that discourage the construction industry from utilising a CPE at the moment. Furthermore, either the authors' survey results in 2002 or the current CPE practice in construction, both indicated that 'client support and involvement' was the most important factor that contributes to successful CPE implementation.**

I. INTRODUCTION

Construction is usually a temporary multi-organisation process, which is heavily dependent on the exchange of large complex data and information. The successful completion of the project depends on the accuracy, effectiveness and timing of communication and the exchange of infor mation and data between the project team [1-4]. The term 'Construction Project Extranet' seems to be the construction buzzword during recent years. These days, it is rare to find a large construction project that is not using some form of electronic system for distributing documents [5]. According to a study by Ross Sturley, marketing director for Emap Construction Network, 25% of projects over £1 million capital value use an Extranet, a further 50% incepted now use the CPE [6]. Paul Smith, chief executive of BIW Technologies agreed, "CPEs have become more popular, 45% of new projects are using them" [7]. Furthermore, industry analysts predict that CPEs will overtake Electronic Data Interchange (EDI) in the next five years. By the end of 2002, CPEs are expected to replace 40% of existing business-to-business systems. And 80% of new business-to-business operations will be implemented using Extranets [8]. The use of Project Extranets is one of those electronic applications that has the potential to change the way that construction does business. Everyone on the project team, wherever they are, can share and track information [9].

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CPEs have been around for a while, and pioneering firms such as Laing and Bovis started using private ISDN (Integrated Service Digital Network) networks some years ago for private, web-based collaboration and document exchange. But the increased availability of cheaper and higher performance systems, along with better quality software and a change of attitude in the industry, has boosted the market [10]. Many companies' first major experience of the Internet is likely to be through on-line project collaboration, and it is this area, according to Crates [11] which is likely to drive the rest of the Information Technology (IT) revolution.

The importance of CPEs to the construction industry is reflected in the very thin margins of 1% to 2% currently made on construction projects [12]. Many application service providers (ASPs) claim savings of 1.3-5% of construction costs through the use of these systems [13-16]. In addition, many research studies have been undertaken to establish what benefits can be contributed to using an extranet [3, 7, 17-25]. The studies have concluded that one of the main advantages of using a CPE is that it ensures that all members of the project team have access to the most up-to-date versions of the various project documents. This means that traditional mistakes generated from someone working from an old document or drawing are in theory removed or at the very least reduced.

This paper addresses the emerging phenomenon of performing project management on the Internet. It is also critically examines the barriers that discourage the Construction Industry from utilising a CPE.

II. The Authors' Survey Results

Construction projects consume significant time and resources in preparing and distributing documentation and in communicating with the team to ensure that everyone is working to the same up-to-date information. Collaborative working is therefore now a widely recognised concept in construction but achieving it is not easy. The web-based Project Collaboration tool (also known as a CPE) is a supply chain integration technology. It provides a secure project-specific website based around a knowledge database. Every team member uses the website for creating and sharing all project data. It is also designed to address the communication challenges of today's construction industry.

The aim of the authors' survey is to explore the use of state-of-the-art project management tools used on UK construction projects. The findings obtained from the authors' questionnaire survey between July 2002 and October 2002, with contributions received from two hundred and thirteen respondents (see Table 1) representing UK construction clients, construction companies, architects and IT consultants, representing an overall response rate of 61%.

Table 1
Questionnaire response rate

Categories	No. sent	No. returned	Response rate
Construction Company	120	72	60%
Client	30	18	60%
Architect	100	61	61%
IT Consultant	100	62	62%
Average	350	213	61%

The authors' survey questionnaire was divided into the six following sections, as presented below and the responses are discussed under these headings:

1. Choosing the right system
2. The appropriate level of cost and charging structures
3. The noticeable benefits that have been gained from using a Construction Project Extranet
4. The barriers that discourage the construction industry from utilising a Construction Project Extranet
5. Product standardisation
6. Creating a formula for success

A. Choosing the Right System

There are around 20 organisations/ASPs (Application Service Providers) offering project collaboration solutions in 2002; together they are supporting over 1,500 'paying' projects, with some 25,000 users [26]. Choosing between them is difficult; therefore, the factors that construction professionals have to consider when choosing a Construction Project Collaboration Extranet is important.

The authors' survey results revealed that 'system simplicity and ease of use' (4.46), 'system reliability and flexibility' (4.46), 'central server with a fully backed-up facility' (4.22) and 'system protected by encryption and virus-proof' (4.15) were considered to be the four most important factors in choosing the right system. The 'system's track record and reputation' and 'speed of information transfer and delivery' ranked fifth and sixth respectively (See Table 2). The results found in the authors' survey were also confirmed by a separate survey conducted earlier by the Cornell Theory Centre research [14], that is simplicity and ease of use as well as speed of information transfer and delivery are the most important factors identified by UK construction professionals in choosing an e-Project management system

Table 2
Factors in choosing the right system - response analysis

Categories	**Construction Company**	**Client**	**Architect**	**IT Consultant**	**Average**
System simplicity and ease of use	4.59	4.17	4.55	4.32	**4.46**
System reliability and flexibility	4.59	4.28	4.33	4.49	**4.46**
Central server with a full backed-up facility	4.17	4.17	4.15	4.36	**4.22**
System protected by encryption and virus-proof	4.21	4.44	4.13	4.00	**4.15**
System's track record and reputation	4.27	3.94	3.88	4.13	**4.09**
Speed of information transfer and delivery	4.14	3.94	4.10	4.00	**4.07**
Defined cost	4.16	4.33	4.02	3.85	**4.04**
Dependability of audit trails	3.99	3.94	3.83	3.79	**3.88**
Ability to handle large numbers of concurrent users accessing large volumes of data	3.86	3.89	3.67	4.00	**3.85**
Financial stability of provider	3.89	3.78	3.78	3.64	**3.78**
Minimal investment in time and money	3.50	3.33	3.73	3.40	**3.52**
PI insurance provision by provider	3.49	3.61	3.62	3.31	**3.48**
Limited training requirements	3.41	3.50	3.57	3.35	**3.45**
Construction experience of provider	3.57	3.47	3.20	3.13	**3.33**
Bespoke solution potential	3.35	3.39	2.90	2.98	**3.11**
Footnote: In a rating of 1 to 5 where 5 is most important, 1 is least important.					

In a market flooded with confusion and choices, selecting the right system is especially difficult. Many companies have suffered the 'betamax' effect of investing in new systems only to find they are out of date and incompatible in a matter of months [27]. Indeed, some construction organisations are saving a fortune by using electronic collaboration, others are not. The key to success is in making the right selection of provider, but the question is how to select the best one [14].

The authors' survey has identified that the four most important factors in choosing the right system are

- System simplicity and ease of use
- System reliability and flexibility
- Central server with a fully backed-up facility
- System protected by encryption and virus-proof

These findings provide a 'guidance of requirements', which will help construction organisations to judge which system is most appropriate for their project.

B. The Appropriate Level of Cost and Charging Structures

The majority of Extranet providers charge a flat monthly rate for the duration of a project. The price of such applications range from £150 per month to £2,200 per month (for a typical £5 million, 12-month building project) depending upon the level of functionality, the number of users and an estimation of the data storage required.

The authors' survey results revealed that the majority of respondents (70%) indicated that a reasonable monthly price for a typical £5 million, 12-month building project, 1Gb (Giga bites) data storage space and up to 250 system users is between £250 and £999. A further 21% reported that a reasonable level of monthly rate is between £1,000 and £1,499, only a small share of respondents (9%) believed that an appropriate level of monthly price is greater than £1,500 (See Table 3 and Figure 1)

One respondent further commented, "Current experience running a £10 million project will cost about £95,000 to £105,000 for 12-months. This is cost prohibitive to a construction company."

It is interesting to note that the architects were very decisive in their opinion (78%) that a reasonable monthly price for a typical £5 million, 12-month building project, 1Gb data storage space, and up to 250 system users, is between £250 and £999. This also accorded with the views from the clients (75%).

The findings in the authors' survey have also concurred with an earlier study carried out by Sturley [25] who identified that the general costs of the system range typically between 0.1% to 0.5% of the total project costs. The figure of 0.5% was deemed high by Abbott [28] who commented, "All the electricity used on a large scale site is just 0.75% of a tender, so 0.5% for a software system is hard to justify."

C. The Noticeable Benefits that Have Been Gained from Using a Construction Project Extranet

Construction Project Extranets are a mainstream project collaboration tool in the UK construction industry with 55% of UK construction professionals in the authors' survey indicating that they have experience of using a Project Extranet. The figure of 55% in the author's survey was also confirmed by a separate survey carried out earlier by the Construction Confederation [20], showing that project collaboration is increasing rapidly with 23% of companies with over 250 employees and 43% of companies with over 1,000 staff using project collaboration tools.

Table 3
Reasonable monthly price of Project Extranet - response analysis

Categories	Construction Company	Client	Architect	IT Consultant	Average
£250 ~ £999	71%	75%	78%	60%	70%
£1000 ~ £1499	19%	19%	17%	27%	21%
£1500 ~ £1999	7%	0%	5%	8%	7%
£2000 ~ £2200	3%	6%	0%	5%	3%

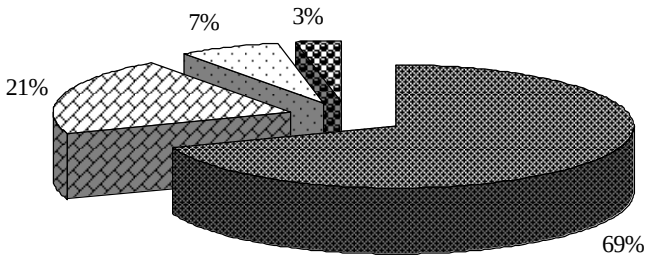

Fig. 1 Reasonable monthly price of Project Extranet

The authors' survey respondents were also invited to rate the level of benefit in improving the effectiveness of project management from the various functionalities offered by the CPEs. The mean rating on the level of benefit were calculated, (on a scale of 1-5) which revealed that 'provides up-to-minute project information' (4.16) and 'improving distribution of information' (4.15) were identified to be the most noticeable benefits that have been gained from using CPEs. These were followed by 'provides a collaborative environment' (3.75), 'improving team communication' (3.72), 'knowledge can be permanently stored' (3.70) and 'increasing design process efficiency' (3.41).

Some respondents also added that 'enables better time management due to reduced interruptions' as well as 'provides electronic drawings with revision control' were also the noticeable benefits that have been gained from using CPEs.

65% of mistakes in the construction industry are due to a misunderstanding among architects, contractors and subcontractors over information, according to Bjornsson [29]. Oliver [15] further commented, "The general statistic is that 80% of mistakes stem from not using the most up-to-date information."

The authors' survey has identified that one of the main advantages of using a CPE is that it ensures that all members of the project team have access to the most up-to-date versions of the various project documents. This means that traditional mistakes generated from someone working from an old document or drawing are in theory removed or at the very least reduced.

However, many of the respondents comments emphasised that cost benefits are not fully realised yet and that it is difficult to predict cost savings at this early stage. In order to test the veracity of the hypotheses and to be able to quantify the overall cost savings a further question was asked to query what percentage of the total project cost saving can be attributed to using an Extranet.

Table 4 and Figure 2 revealed that a significant proportion of respondents (50%) reported that less than 1% of the total project cost saving can be attributed to using a CPE. A further 23% believed that cost savings of between 1% and 2% are possible, and only a small share of respondents (10%) indicated that tangible savings between 2% and 3% of the total project cost are possible. The authors' survey results were also confirmed by research carried out earlier by Cadweb [14], showing that for a £10 million building project, a cost saving of £80,000 (0.8%) can be achieved.

The authors also received a comment that highlighted the negative effects of cost savings: "We see no tangible savings to production cost for use of limited extranet. Main advantage is some time savings in document and drawing transfer."

Improvements have been made in the UK construction industry by utilising CPE. Kajima UK for example achieved a 10% reduction in overall construction costs, and brought the construction time down from 17 weeks to 12. The project architect alone identified £31,000 of savings as a direct result of using a CPE, according to Smith [7]. Another example is Kier Contractor who achieved £50,000 direct savings on printing, information distribution and general communication by using a CPE on a £60 million fast track commercial development project [15].

Table 4
Percentage of the total project cost saving – response analysis

Categories	Construction Company	Client	Architect	IT Consultant	Average
<1%	50%	72%	46%	49%	**50%**
1% ~ 2%	21%	14%	26%	24%	**23%**
2% ~ 3%	8%	0%	8%	15%	**10%**
3% ~ 5%	13%	0%	6%	3%	**7%**
5% ~ 10%	5%	14%	6%	9%	**7%**
>10%	3%	0%	8%	0%	**3%**

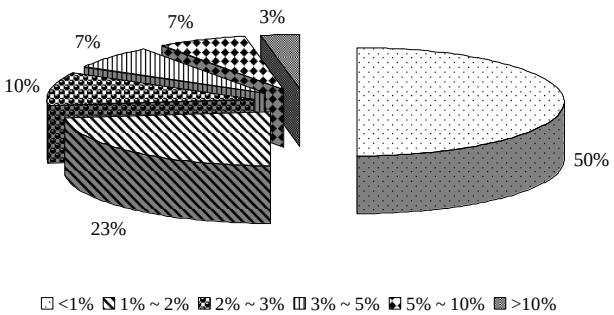

Fig. 2 Percentage of the total project cost saving

e clearest cost saving comes from cutting down on the number of drawings printed and posted or sent by courier. However, project collaboration extranet does not do away with the need for printed drawings entirely. Therefore, it must be realised that some cost and effort is transferred from one party to another.

To assess the true value of the saving in this area is very much dependent on the team in question. Many different factors need to be considered. However, even if there was only a 30% reduction in this area, a cost saving of 0.24% (0.8%x30%=0.24%) can be achieved on a £10 million building project, according to Cadweb [14]. This was also confirmed by a report 'Collaboration software in the construction industry' Compagnia Consultants [30], which suggests that the adoption of collaboration software throughout the construction industry could reduce costs by at least 4.28%.

D. The Barriers that Discourage the Construction Industry from Utilising a Construction Project Extranet

The barriers discouraging the effective use of CPE in the UK construction industry have been identified in the authors' survey. The results are illustrated in Table 5, and indicate that the four most significant barriers are:

- Current work practice culture
- Familiarity and reliance upon hard (paper) information
- Lack of awareness of the benefits of Project Extranets
- Integration problems of systems between the team members

These findings concur with the study carried out by Goodwin [19], Alshawi & Ingirige [23], Oliver [15] and Sturley [25] who identified similar barriers to effective project collaboration as

- Unawareness of the benefits of Project Extranet
- Lack of necessary skills, experience or technology
- Reluctance to use different systems on different projects
- Low confidence in the systems that are used

However the order of importance of the various barriers is slightly changed.

Table 5

Dependence levels of barriers - response analysis

Categories	Construction Company	Client	Architect	IT Consultant	Average
Current work practice culture	4.28	4.18	4.07	4.13	**4.16**
Familiarity and reliance upon hard (paper) information	4.14	4.13	3.79	3.95	**3.98**
Lack of awareness of the benefits of Project Extranet	3.90	4.06	3.56	4.05	**3.86**
Integration problems of systems between the team members	3.86	3.82	3.85	3.41	**3.72**
Speed of connection	3.83	3.67	3.38	3.57	**3.61**
Team members having different degrees of IT knowledge	3.64	3.65	3.37	3.34	**3.47**
Long-term benefits difficult to quantify	3.35	3.53	3.31	3.37	**3.36**
Professional Indemnity insurers do not allow the companies to rely solely on electronic records	3.18	3.59	3.21	3.45	**3.30**
Increased cost contribution required from sub-contractors compared to traditional paper-based systems	3.19	3.41	3.22	3.17	**3.21**
Security issues	3.01	3.35	3.08	3.21	**3.12**
Conversion of information to suit digital format distribution	3.28	3.53	2.82	3.05	**3.10**
Lack of access to project data over the Internet	3.10	3.47	2.93	2.90	**3.02**
Legal issues	3.01	3.12	3.00	3.00	**3.01**
Many parties involved	3.01	3.47	2.97	2.85	**2.99**

Footnote: In a rating of 1 to 5 where 5 is most obstacle, 1 is least obstacle.

E. Product Standardisation

Legal and security issues restrict some construction organisations from committing to one provider. Consequently they will require re-learning and re-training in the use of different technology. At the risk of creating a monopolistic situation, it is worth considering the development of 'one standard product' that would be suitable for all projects in the future.

Table 6 and Figure 3 indicate a diverse range of responses. Most respondents (43%) agreed that developing 'one standard product' is important for all projects in the future. A further 7% revealed that they 'strongly agree' in developing 'one standard product'. Twenty-four percent of respondents disagreed with developing 'one standard product' due to the risk of creating a monopolistic situation and a further 14% 'strongly disagreed'. Overall, 12% of respondents indicated that they were 'undecided'. The architect respondents were very emphatic in their opinion (56%+10%=66%) that developing 'one standard product' is important for all projects in the future. It is substantially more extensive than the views expressed from the respondents representing the other three categories. It is suggested that because the architect respondents were more experienced in using different systems on different projects they therefore acquired re-learning skills in the use of different technology

Table 6
Developing one standard product - response analysis

Categories	**Construction Company**	**Client**	**Architect**	**IT Consultant**	**Average**
Strongly disagree	16%	22%	8%	15%	**14%**
Disagree	21%	22%	18%	32%	**24%**
Undecided	14%	17%	8%	13%	**12%**
Agree	42%	28%	56%	37%	**43%**
Strongly agree	7%	11%	10%	3%	**7%**

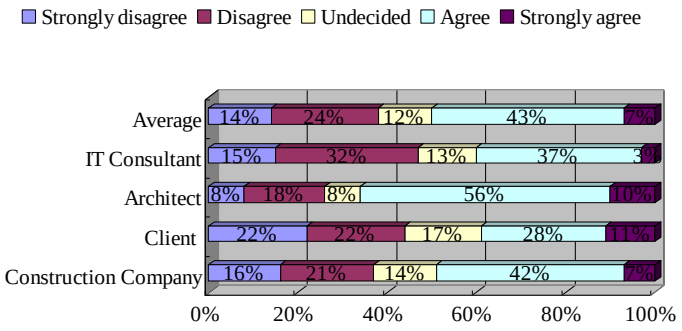

Fig. 3 Developing one standard product

Eight UK application service providers: BuildOnline, Causeway, Cadweb, Sarcophagus, BIW, 4Projects, Business Collaborator and Bidcom are combining to form an industry group, as yet unnamed. The group will promote the use of online project collaboration tools, and aims to develop industry standards so that customers will be able to transfer data more easily between systems [31]. Bishop [12] agreed, "*There is substantial 'lock in' of customers to one particular solution, customers do not want to have to relearn and retrain on a solution each time they change projects*

F. Creating a Formula for Success

CPEs represent the first wave of the e-Commerce revolution for UK construction, with usage of these web-based communication and data exchange tools predicted in 2001 by Sturley [25] to expand rapidly.

The authors' survey was also designed to explore the respondents' awareness of CPEs and to indicate what factors contribute to successful CPE implementation. The survey results revealed that 'client support and involvement' (4.41) and 'choosing the right system' (4.39) were the most important factors that contribute to successful CPE implementation. The 'early demonstration and training to all the team' and 'ensure that all of the project trading partners are aware of the intention to implement a Construction Project Extranet during the tender process' ranked third and fourth respectively (See Table 7).

One respondent further highlighted the importance of client support and involvement; "*We are a small to medium contractor working for a variety of clients, main contractors, and developers in our local region. We are only just beginning to communicate by email with our clients. Most of our clients do not require us to have much in the way of electronic systems in place and therefore we have not had to ponder the route of electronic project management systems such as the extranets*."

III. Current Practices For CPE In Construction

Eleven recent surveys [32-42] of contractors, clients and suppliers conducted between 2003 and 2008 showed increasingly enthusiasm in construction for the widespread use of CPE.

Eleven survey results have been classified under the following headings:

- Benefits of Construction Project Extranets

- Product standardisation
- Barriers that influence the implementation of Construction Project Extranets

A. Benefits of Construction Project Extranets

According to research by Joe Martin [32], the majority of respondents to this research felt that using CPEs improved the process, communications and service to clients and they seemed clear as to what these improvements were. A further study carried out by Daniel and Elling [34] showed that CPEs provide tremendous time and cost savings, and therefore a substantial return on investment (ROI); offer significant benefits in case coordination, and are an easy, inexpensive, and robust means of communication with client

Table 7
Dependence of levels of successful implementation

Categories	Construction Company	Client	Architect	IT Consultant	Average
Client support and involvement	4.51	4.56	4.15	4.52	4.41
Choosing the right system	4.44	4.50	4.34	4.36	4.39
Early demonstration and training to all the team	4.23	4.00	4.20	3.98	4.13
Ensure that all of the project trading partners are aware of the intention to implement a ConstructionProject Extranet during the tender process	4.14	3.72	4.05	4.20	4.10
On-going review and continual improvement	3.93	3.72	3.39	3.64	3.67
Total commitment to supply chain philosophy	3.56	4.06	3.71	3.61	3.66
Successful integration of existing business systems	3.46	3.72	3.66	3.66	3.60

Footnote: In a rating of 1 to 5 where 5 is most important, 1 is least important.

Recently, a research conducted by the Network for Construction Collaboration Technology Providers [38] shows that project teams are increasingly demanding contractors with experience of using CPEs.

One of the more tangible benefits the research team discovered was the reduction in time taken to approve drawings. Overall, construction projects saved almost 26% of the time usually taken to approve project drawings, down from an average of 9.3 days to just 6.9 days. Improved accountability, better project management, improved document control and ease of completed project hand-over were also cited as core benefits of using CPEs.

Furthermore, a questionnaire survey in the form of a structured, face-to-face interview was conducted by Chan and Liu [39] revealed that the top 5 noticeable benefits identified by the interviewees are: improving team communication (78% of the 32 interviewees agreed); improving distribution of information (71%); increasing productivity (52%); and providing a collaborative environment (52%). It is also the case in research carried out by Mitchell and Demain [41] showed that the use of CPEs made communication, RFI process, drawing review and issuing, document management and file storage more efficient and effective, and meeting the requirements of end users. This supports the main benefits also identified by the authors' survey in 2002.

Almost all of respondents in the Martin [32] survey would use CPEs again on future projects. In addition, the majority of respondents thought that CPEs were a more effective way to share information compared with traditional methods but they did not think that this necessarily improved the relationships between project members.

IV. Product Standardisation

According to the authors' survey in 2002, the majority of respondents (50%) agreed that developing 'one standard product' is important for all projects in the future. Recently, a research conducted by Moses et al. [40] revealed that clients desire to move their projects between different project collaboration systems for a number of reasons, examples of reasons are as follows:

- The vendor is unable or unwilling to continue the service that they are currently providing and the client needs to transfer project data to another supplier.
- When selecting a system, the client undertook projects on a number of different systems to evaluate the products and wishes to move all the projects to the single selected system.
- The project on the extranet has been completed and the client wishes to bring the data in to their enterprise system for all employees to utilise the captured data.
- In order to address these client concerns with project collaboration systems a group of vendors formed the Network of Construction Collaboration Technology Providers (NCCTP), an association focused on developing standards that would aid data transfer between different systems and lead to a greater uptake of collaborative technology in the UK construction sector. Initially containing 6 collaborative vendors, the NCCTP has now grown 9 members and is one of the projects managed by the British Construction Industry Research and Information Association (CIRIA)[40].

A. *Barriers That Influence The Implementation Of Construction Project Extranets*

The barriers discouraging the effective use of CPE in the UK construction industry have been identified in the authors' survey as mentioned earlier. The authors' survey results concur with a recently survey carried out by Mitchell and Demian [41] who identified similar barriers to effective project collaboration as:

- Technical barriers: The Mitchell and Demian survey results have highlighted that extranets are not delivering the speed of service required, 32% of respondents found extranets to be very slow, with 36% finding them slow and only 32% of respondents finding them fast, with not one respondent finding them very fast. This is a barrier that is restricting the successful use of extranets.
- People barriers: Recently, a study conducted by Daniel and Elling [34] indicated that tools are useless without the right people. Wilkinson [36] agreed and stated that "*80% on tackling the people issues and 20% on resolving the technology aspects*." The Mitchell and Demian [41] survey results also show that 71% of users only received two hours or less of training, and 66% of respondents identified that the training received was insufficient to enable successful operation of the extranet.
- Managerial barriers: The survey results revealed that client support for CPE's use is low. One interviewee in the Mitchell and Demian [41] survey commented that "*You have to be able to explain to clients that spending £30k or £40k on an extranet will benefit the project. This is difficult because a lot of the benefits are intangible, for example the speed of information flow and secure audit trail, gaining client support is critical to the extranet's success*." The role and support of the client is critical to CPE success. In the majority of cases they are funding the CPE. If clients are not committed and supportive to the use of extranets then neither will the contractor. These findings also concur with the authors' survey in 2002. The survey results indicated that 'client support and involvement' was the top 1 important factor that contribute to successful CPE implementation.

B. *Opportunities for Construction Project Extranets on Future Development in Construction*

The evaluation of Information and Communication Technology (ICT) in particular with respect to World Wide Website (WWW) remains an important process that requires careful management and control. Cheng et al. [43] suggests that the strategic decision to adopt project collaboration tool requires a construction organisation to re-examine their business operations as well as their business relationships with clients/customers, subcontractors and suppliers.

Currently, one of the major issues facing CPE is the ability to create user confidence in the security of extranet transactions. In addition, a secure way of sharing project information is also crucial for businesses to carry out on-line project management with their business partners and clients.

According to research by Paul Wilkinson [36], head of corporate communications at BIW technology UK, the majority of respondents had seen success with CPEs and were committed to using the technology in future. The research also found a significant proportion of respondents were satisfied but uncommitted to using the technology. Many of these tended to be sub-contractors.

"Often bought on board when the project and the extranet is already up and running, many sub-contractors receive little knowledge and training on how to use the technology," believed Wilkinson. Therefore, one of the key challenges the industry now faces is encouraging these project team members that extranets are the way forward.

Wilkinson further commented that "*the industry as a whole needs to address the people and processes issue by thinking about the demands on sub-contractors early in the programme and allowing for some proper training. We need to consider the needs of the sub-contractor as part of the implementation of the technology.*"

A further study carried out by Yeomans et al., [44] argued that extranets should strive towards a collaborative working environment. 46% of users considered extranets to be a comprehensive electronic data management tool, but only 25% considered them to be a means to achieve project collaboration.

Downing [45], e-strategist with BT stated that; "*This market is seriously immature. It is a much more complex market than people thought. Supply chain management is a lot more complex than just going online.*" But one thing is certain; CPE will have a major impact on the industry and no one seems to doubt that construction will implement ICT in the end.

However, there are still so many opportunities and choices in the e-market. New ASPs are still being launched. Lamont [46], former chief executive of the Confederation of Construction Clients (CCC) stated. "If we are going to secure long-term improvements in our industry's performance, we must seek to standardise our processes, and one way to do this is through the adoption of new technologies." She added, "We believe that the increased use of electronic processes for procurement and supply chain integration will help to strip out unnecessary duplication and waste. This will lead to improved margins for suppliers and lower prices for clients."

Construction Best Practice Programme [47] as an example, stated that during 2002 UK construction organisations that engaged in Best Practice increased profitability by £56 million, an average of £15,000 per company. Companies implementing Best Practice have seen profits increase by 50% relative to those not applying these principles. A key contributor to this process improvement is the sharing of project information. Huge savings can be made simply by ensuring that all members of the project team receive accurate drawings and everyone is working to the same, up to date, information [48].

V. Conclusion

This paper has presented the findings of a questionnaire survey conducted by the authors among a sample of 350 construction professionals based in the UK. The survey results, received from 213 respondents demonstrate that 55% of UK construction professionals have experience of using a CPE. The main benefits of this technology are that it; 'provides up-to-the-minute project information', 'improves distribution of information' and 'provides a collaborative environment'.

The findings in the authors' survey have also concurred with recent survey carried out by Chan and Liu [39] who identified that the top 5 noticeable benefits are: improving team communication; improving distribution of information; increasing productivity; and providing a collaborative environment.

In addition, the three most important factors that contribute to successful Project Extranet implementation in the UK construction industry have been identified in the authors' survey as:

- Client support and involvement
- Choosing the right system
- Early demonstration and training to all the team
- Mitchell and Demian [41] agreed and stated that "the role and support of the client is critical to CPE success. In the majority of cases they are funding the CPE. If clients are not committed and supportive to the use of extranets then neither will the contractor."

The last word can be summarised by one respondent's comment in the authors' survey: "In my experience, clients and teams try and achieve every possible objective with these technologies. Most see them as an electronic postbox and therefore evaluate them on the basis of ease of use and compliance with existing processes. However, the main objective for a number of providers is to change the way organisations work for the better."

VI. Acknowledgment

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Teletraffic Modeling of Cdma Systems

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***Abstract*-This paper presents teletraffic modeling of Code Division Multiple Access (CDMA) systems that enabled the analysis of such systems capacity. Analytical tools aided by software model that assisted in analysis of the system performance, capacity estimation, dimensioning and design of CDMA networks were achieved. This work, therefore, focused on modeling telephone traffic for analysis of CDMA cellular network capacity. We developed an analytical expression for blocking probability and consequently that for the determination and analysis of the capacity of CDMA networks. The analyses of obtained results showed how interference determined the capacity of CDMA networks and therefore proved that the capacity was not hard limited, but depended on predetermined quality of service for the network. Also, the result showed how the capacity of the network, in terms of number of subscribers, can be estimated for CDMA networks. Graphical results generated from the blocking model showed the effect of variations in interference parameters on CDMA capacity. The Erlang capacity from the model was adapted into Erlang B formula to estimate capacity in terms of channels, and the number of subscribers a typical CDMA sector could accommodate.**

Keywords-Teletraffic, mobile Traffic modeling, CDMA network, mobile network

I. Introduction

In a world of finite spectrum resources, CDMA enables many more people to share the airwaves at the same time than do alternative technologies [1]. The capacity of CDMA systems with respect to the possible number of supportable users can be utilized for radio resource management, such as call admission control (CAC) or resource allocation for ongoing calls as well as for a measure of revenue. CDMA development was mainly for capacity reasons and the success of the technology depended on huge increased in the capacity that is not hard limited but interference limited [2, 3]. The term teletraffic covers all kinds of data communication traffic and telecommunication traffic [4]. This paper discussed teletraffic modeling of CDMA systems that enabled the analysis of CDMA systems capacity, leading to analytical tools aided by a software model which assisted in performance analysis, capacity estimation, dimensioning and design of CDMA networks.

II. Materials and Methods

We studied and analyzed CDMA Erlang capacity vis-à-vis probability of blocking and then derived blocking probability formulas later plot their graphs of the relationship for analysis. The derived formulas were instrument for capacity analysis in CDMA networks. Comparative analyses were carried out to compare the two approximation methods on the basis of determining which preference will be given to obtain best results. We applied approximation methods on the basis of determining which preference will be given to obtain best results. We applied the Erlang B probability statistics into CDMA networks to calculate capacity in terms of number of channels and subscriber capacity in a cell or sector, for network planning and dimensioning applications.

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III. CDMA Blocking Probability Modeling

In the conventional modeling of telephone traffic, assuming M for subscribers, N for available lines, λ for average rate of arriving calls (calls/sec), T for average call length in seconds and μ average for departure rate (calls/sec). As the random call traffic arrives and departs, the number of lines occupied by ongoing calls can vary from 0 to N. The number of lines occupied is restricted to 0<k< N, where k is the active call per time.

If calls are rejected when all N lines are occupied, then P_k for the case of k = N; P_k is the probability that a call is rejected or "blocked" for M >> N

$$B=P_N=\frac{(\lambda/\mu)^N/N!}{\sum_{k=0}^{N}(\lambda/\mu)^k/k!}=\frac{A^N/N!}{\sum_{k=0}^{N}A^k/k!} \quad (1)$$

where B is the Erlang B formula,

The expression (1) above is for the blocking probability and known as the *Erlang B* formula [5]. The traffic load in Erlangs (A) is given as

$$A=\frac{\lambda}{\mu}\frac{(call/sec)}{(call/sec)} \quad (2)$$

For a finite M users **A** (the traffic load in Erlang) can also be expressed in Terms of ρ**,** the fraction of time that each user occupies a telephone line [6, 7, 8, 9]. Thus

$A = M_{\rho}$. (3)

In a single cell, if C is the carrier power, I given as the interference power at the base station, W the transmission bandwidth and N_0 the interference power spectral density, then neglecting thermal noise the interference power caused by the (M – 1) interferers is given as

I = C* (M – 1) (4)

Then, the capacity of the CDMA is found to be as given in equation (5) below

$$M \approx M-1=\frac{W}{R}\cdot\frac{1}{E_b/N_0} \quad (5)$$

Thus, the capacity of CDMA is proportional to the processing gain.

A CDMA blocking model was developed as a tool for the analysis of the capacity of CDMA cellular networks. Erlang B model can be applied directly to the reverse links of FDMA and TDMA systems. However, the number of channels in a CDMA cellular system is not fixed and therefore, the mechanism for blocking in a CDMA cellular system [9] needed to be examined before an application of the Erlang B theory for its capacity analysis. We determined the CDMA Erlang capacities using two different

distributions for the total user interference power: Gaussian and lognormal approximations.

received at the base station can be written as expression (6) below:

$$\underbrace{\alpha_{r1}P_1+\alpha_{r2}P_2+\ldots\ldots+\alpha_{rM}P_M}_{M\text{ reverse link signals}}+\underbrace{(N_0W)_c}_{\text{noise power}} \qquad (6)$$

where,

the $\{\alpha_r\}$ is random variable representing the reverse link voice activity, which have the experimental values given as $E\{\alpha_{ri}\} = \overline{\alpha_r} = 0.4$ and $E\{\alpha_{ri}^2\} = \overline{\alpha_r^2} = 0.31$

the$\{P_i\}$ are the random signal power for the M active users.

the number$\{\alpha_{ri}\}$ of signals M is itself a random variable (RV), assumed to have a Poisson distribution, so that $E\{M\}=\bar{M} = Var\{M\}$

$$Z \triangleq \sum_{i=1}^{M} \alpha_{r1}\,\rho_i = \frac{W}{R_b}(1-\eta) \qquad (7)$$

$$B_{CDMA} = Q\left(\frac{\ln\left[\frac{W}{R_b}X_0\right]-\ln[\bar{M}\,\overline{\alpha_r}\,(1+\xi)]-\beta m_{dB}}{\sqrt{\ln\left[\frac{\overline{\alpha_r^2}(1+\xi')e^{\beta^2\sigma_{dB}^2}}{M(\overline{\alpha})^2(1+\xi)^2}+1\right]}} - \frac{\frac{1}{2}\left\{\beta^2\sigma_{dB}^2-\ln\left[\frac{\overline{\alpha_r^2}(1+\xi')e^{\beta^2\sigma_{dB}^2}}{M(\overline{\alpha})^2(1+\xi)^2}+1\right]\right\}}{\sqrt{\ln\left[\frac{\overline{\alpha_r^2}(1+\xi')e^{\beta^2\sigma_{dB}^2}}{M(\overline{\alpha})^2(1+\xi)^2}+1\right]}}\right) \qquad (11)$$

Thus with this, we had Erlang capacity formulas for CDMA cellular system under two separate approximations for the interference statistic: Gaussian approximation, by invoking the central limit theory (CLT), and lognormal approximations, on the assumption that the sum of M lognormal random variables (RVs) is also a lognormal of random variable. The blocking probabilities are expressed as a function of the interference parameter threshold η_0 and then the cell loading threshold X_0.

We now considered a single, isolated CDMA cell with M active users. The total reverse link signal-plus-noise power

$$\rho_i \triangleq E_{bi}/I_0' \qquad (8)$$

and $\eta \triangleq \frac{N_0}{I_0'}$ (thermal noise) (9)

The interference due to mobiles in other cells can be accounted for by using first- and second-order *frequency reuse factors* $F = 1 + \xi$ and $F^1 = 1 + \xi'$, respectively, where the following approximation methods were considered:

Gaussian approximation

The CDMA blocking probability for the interference statistic, was derived as

$$B_{CMDA} = Q\left(\frac{\frac{W}{R_b}(X_0)-\bar{M}\overline{\alpha_r}\rho_{med}\,e^{1/2\beta\sigma_{dB}^2}(1+\xi)}{\sqrt{\bar{M}\overline{\alpha_r^2}\rho_{med}^2\,e^{2\beta^2\sigma_{dB}^2}(1+\xi')}}\right) \qquad (10)$$

In which the Erlang capacity is $\bar{M}$.

Lognormal approximation

In this case the CDMA blocking probability for the interference statistic, was derived as

Analysis Of Results

From equation (10) we plot BCMDA versus $\bar{M}$ for a single cell ($\xi = \xi' = 0$) and for multiple cells ($\xi = \xi'$ =0.55) using the following typical parameter values: σ_{dB}=2.5dB, m_{dB}=7dB, W=1.2288MH, Rb=9.6kbps, X0= 0.9, $\overline{\alpha_r}$ =0.4, $\overline{\alpha_r^2}$ =0.31. The plots are parametric in $m_{dB} = E_b/N_0$, which takes the values 5, 6 and 7dB

TABLE 1 SNR requirement varied (Gaussian approximation)

ERLANG CAPACITY	$m_{dB} = E_b/N_0 = 5$dB		$m_{dB} = E_b/N_0 = 6$dB		$m_{dB} = E_b/N_0 = 7$dB	
	Multi cell	Single cell	Multi cell	Single cell	Multi cell	Single cell
	BLOCKING PROBABILITY		BLOCKING PROBABILITY		BLOCKING PROBABILITY	
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
20	0.0636	0.0000	0.0005	0.0000	0.0266	0.0000
30	0.5550	0.0000	0.0933	0.0003	0.4225	0.0189
40	0.9063	0.0002	0.5217	0.0202	0.8483	0.2015
50	0.9878	0.0097	0.5217	0.1654	0.9768	0.5449

$$\overline{\propto_r} = 0.4, \quad \overline{\alpha_r^2} = 0.31 \quad X_0 = 0.9, \frac{W}{R_b} = 128$$

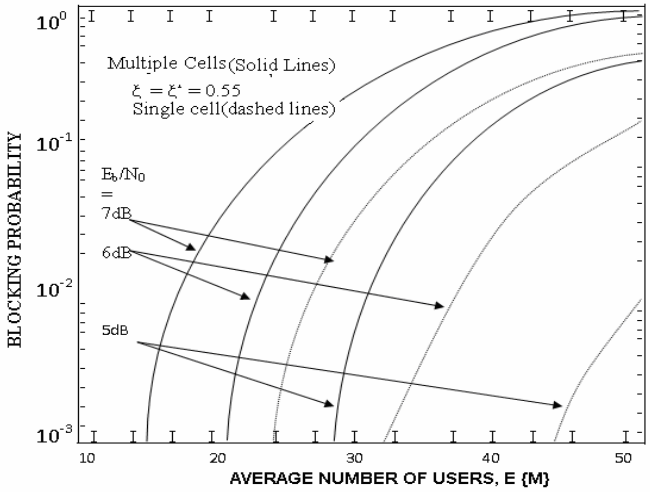

Figure 1 CDMA blocking probability (Gaussian approximation) versus average number of mobile users, SNR requirement varied

From Figure 1, we observed that the value of Eb/N0 needed for link operations affects the average number of users that can be accommodated at a given level of blocking. Raising the Eb/N0 requirement increases the blocking probability for the same value of M or decreases the capacity for the same probability. For example, when the blocking probability is chosen to be BCDMA = 10 -2 = 0.01 = 1%, for multiple cells, the corresponding value of the Erlang capacity M is 18 for mdB = 7 dB, 24 for mdB = 6dB, and 33 for mdB = 5 dB.

If we denote the Erlang capacity for a single cell by $\bar{M}$c and the capacity for multiple cells by $\bar{M}$, for BCDMA = 1.0% and Eb/N0 = 6 dB, we observed that $\bar{M}$c = 37.5 and $\bar{M}$ = 24.1. The ratio of these values is 37.5/24.1 = 1.56, a value that is approximately equal to the assumed value of the reuse factor, F = 1 + ξ = 1.55. This is consistent with the definition of the reuse factor

TABLE 2 Loading threshold varied (Gaussian approximation)

$m_{dB} = E_b/N_0$	$\overline{X_0}$=0.66		X_0=0.75		X_0=0.9	
ERLANG CAPACITY	MULTI CELL	SINGLE CELL	MULTI CELL	SINGLE CELL	MULTI CELL	SINGLE CELL
	BLOCKING PROBABILITY		BLOCKING PROBABILITY		BLOCKING PROBABILITY	
10	0.0021	0.0000	0.0000	0.0000	0.0000	0.0000
20	0.0763	0.0003	0.0141	0.0000	0.0005	0.0000
30	0.5095	0.0483	0.3413	0.0096	0.0933	0.0003
40	0.9271	0.3169	0.8007	0.1431	0.5217	0.0202
50	0.9978	0.6681	0.9661	0.4629	0.8687	0.1654

$$\overline{\propto_r} = 0.4, \quad \overline{\alpha_r^2} = 0.31, \quad \frac{E_b}{N_0} = 6dB, \frac{W}{R_b} = 128$$

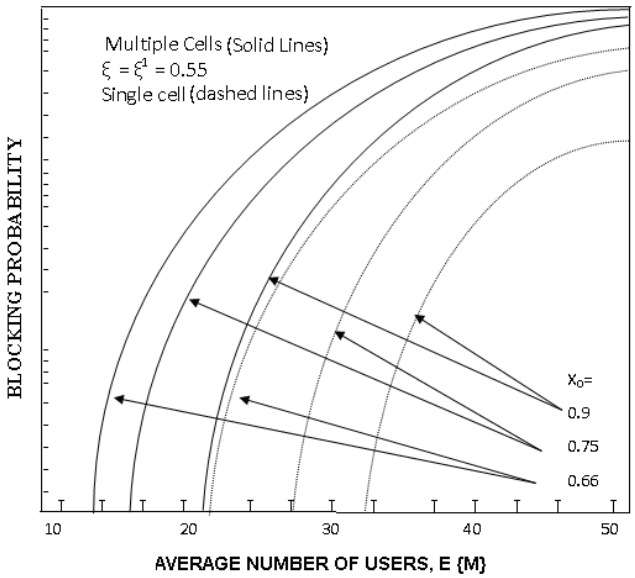

Figure 2 CDMA blocking probability (Gaussian approximation) versus average number of mobile users, loading threshold varied.

Assuming that $m_{dB} = E_b / N_0 = 6$ dB, the effect of varying the loading threshold X_0 on B_{CDMA} and $\bar{M}$ is illustrated in Figure 2, in which X_0 takes the values $X_0 = 0.66$, 0.75, and 0.9. These values correspond to the multiple access interference power being twice, three times, and nine times as strong as the thermal noise. Raising the loading threshold has the effect of relaxing the system requirements, and is seen in Figure 2 to result in either a decrease in the blocking probability for the same value of $\bar{M}$, or an increase in $\bar{M}$ for the same value of B_{CDMA}. If we substitute specific numerical parameter values into the general equation (10), such as $\sigma_{dB} = 2.5$ dB, $m_{dB} = 7$dB, $W = 1.2288$ *MHz*, $R_b = 9.6$*kbps*, $X_0 = 0.9$, $\overline{\alpha_r} = 0.4$, $\overline{\alpha_r^2} = 0.31$, and we obtain

$$B_{CDMA} = Q\left(\frac{115.2-2.37\ (1+\xi)\bar{M}}{3.89\sqrt{(1+\xi)\bar{M}}}\right) \quad (12)$$

which gives the below form

$$B_{CDMA} = Q\left(\frac{a-b\bar{M}}{\sqrt{c\bar{M}}}\right) \quad (13)$$

Because Q(0) = 0.5, we infer from (13) that the blocking probability is 50% when $\bar{M} = a/b$. This high blocking probability is of course unacceptable, so we know that an acceptable value of blocking probability is realized only when $\bar{M}$ is much less than a/b. It is interesting therefore to note by comparing (10) and (13) that the upper limit on $\bar{M}$ based on having a small blocking probability is

$$\bar{M} < \frac{a}{b} = \frac{\frac{W}{R_b}\,X_0}{\overline{\alpha_r}\,Pmed\;e^{\frac{1}{2}\beta^2\sigma^2}\,dB\,(1+\xi)} = \frac{PG}{E_b/N_0}\cdot\frac{1}{\alpha_r\,F}\cdot\frac{X_0}{e^{\frac{\beta^2\sigma_{dB}^2}{2}}}$$

The ideal CDMA capacity was shown as

$$M = \frac{PG}{E_b N_0}\cdot\frac{1}{\alpha_r F} = \frac{PG}{E_b N_0}\cdot\frac{1}{\alpha_r}\cdot Fe \quad (15)$$

which was valid under perfect power control and omni-directional cell antenna assumptions. Note that under the conditions of perfect power control ($\sigma_{dB} = 0$ dB) and 100% cell loading in the ideal situation ($X_0 = 1$), then the Erlang capacity bound in (14) is equal to the ideal capacity in (15).

IV. Conclusion

The stochastic nature of call arrivals and departures were characterized using statistical means. The interference contributed by each user was modeled as a Poison random variable that summed up to a statistical random variable with Gaussian and lognormal characteristics. In this paper we focused on the analysis of Gaussian approximation, which yielded a simpler result and therefore preferred.

Blocking occurred when the reverse link multiple access interference power reached a predetermined level that is set to maintain acceptable signal quality. When the total user interference at a base station receiver exceeded the set threshold, the system blocked the next user attempting to place a call.

The number of users for which the CDMA blocking probability equaled 1% was taken to be the Erlang capacity of the network. Thus, a new CDMA blocking probability model was developed that enabled the estimation and analysis of Erlang capacity of CDMA networks. Comparative capacity analysis showed that CDMA has a huge capacity advantage over TDMA and FDMA.

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Author Guidelines:

1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript’s Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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Informal Tips for writing a Engineering Research Paper to increase readability and citation

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- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.
- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.

- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.

You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
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- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.

- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

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- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

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The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described.
Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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