

## **Human Risk Factors in Construction**

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### **Abstract**

Human factors are sometimes recognized as the main reason or catalyst for disasters in the construction industry. They also have a considerable influence on the implementation of construction projects on a day-to-day basis. The importance of appreciating and understanding the unpredictable effects of human factors is therefore vital for project or operational success. This paper reports on the results of a research project which was aimed at identifying the significant human factors that influence construction projects. For this purpose a questionnaire survey was designed and distributed to construction practitioners. Through a formal ranking process, the importance of each factor was identified to determine the most significant human risk factors in the procurement of construction projects. The results obtained are presented and discussed with the aim of assisting the industry to take a more holistic view of uncertainty early in projects. The findings of this research will form the basis for an extended investigation which aims to systematically model and simulate the behaviour of these human risk factors and their effects.

### **Keywords**

Human Factor, Risk, Construction

### **1. Introduction**

It is almost axiomatic that design, material, labour, equipment and control parameters are taken to be the most important elements in a construction project and therefore dictate its outcome. However the underlying reasons for the successful or unsuccessful implementation of these elements are human factors, which tends to be ignored. Human factors refer to the unpredictable nature of human behaviour.

There is a generic acknowledgement that human factors are unequivocally the single most important element that can affect project success (Oldfield and Ocock, 1997, Qamber 1998, Egbu 1999 and Thevendran 2001). Many well known disasters are due to human risk factors, for example the Three Mile Island power station disaster (Stain and Preece, 1999) and the Challenger space shuttle explosion (Texas University, 2002). The construction industry has also experienced its fair share of disasters due to human risk factors, for example the collapse of Highland Towers in Malaysia (Lawyerman, 1996), the collapse of the Quebec Bridge (Schaub & Dickison, 1982) and the collapse of Heathrow Express Tunnel (Masurier, 2002). Although human factors are rarely included in risk assessment processes on the grounds that they are difficult to quantify, as much as 80% of all project risks may be human related (Oldfield and Ocock, 1997). It is also imperative to realise that even the minor effects of human factors

can have a substantial contribution to or influence on the implementation of construction projects on a day-to-day basis. The objective of this paper is to highlight these influences and show the various human factors that can affect construction projects. This paper discusses the results of a questionnaire survey intended to identify the most significant human factors.

## 2. Risk

Currently there are two schools of thought into the definition of risks. These are as follows:

- An uncertain event that could have favourable or unfavourable consequences on the implementation of projects. This view takes risk as an umbrella term encompassing opportunity and threat (Hilson 2002). Opportunity is taken to be the favourable effects and threat is taken to be unfavourable ramifications.
- The second paradigm of thought refers to risk as the chance or possibility of an adverse event having an impact on the procurement of a construction project. This notion of risk evolves from the definition of uncertainty which gives rise to opportunity and risk (Dawson, 1997). In this context risk is articulated to be a threat or the possibility of encountering loss in the procurement of a construction project. The exact opposite of risk is opportunity, which is the favourable side of uncertainty as it enhances the possibility for advancement and progress in construction projects. This area of uncertainty has not warranted discussions in many papers involving risk and uncertainty. Hillson (2002) suggested that opportunity and risk are not qualitatively different in nature, since both involve uncertainty which has the potential to affect project objectives.

The second paradigm has been adopted here to define the different influences of human factors. Thus risk in this paper is taken to be an uncertain event with a detrimental impact and opportunity are with a beneficial effect.

## 3. Human Factors and their Influence

The authors define human factors as follows

*“Individual, project team and organizational factors, which influence the behaviour of people and the climate at work, in a way which can increase or decrease the efficiency of a construction project”*

This definition will be utilised throughout this paper. From literature reviewed and a preliminary interview it was possible to classify human factors affecting construction into three distinct groups: individual human factors; project team factors; and organizational factors. The authors have divided human factors into 13 major categories, which are labelled core factors. This includes (see Table 1), six individual core factors (capability, knowledge and skill, stress, motivation, emotional and culture), four project team core factors (management, supervision, task and communication and coordination) and three organizational core factors (policies, standards and systems & procedures). These 13 core factors are made up of 197 human factors (see Table 1). The effects of these human factors in the procurement of construction projects can be divided into three different types: positive factors, negative factors and mixed factors (Thevendran, 2002). From the 197 human factors identified, there were 134 factors that possess a positive influence on construction productivity, 38 factors that have a negative influence on construction productivity and 25 factors that have a mixed influence on construction productivity. These factors are defined below (Thevendran, 2002) along with a relevant example relating to how the third type of factor can affect the procurement of construction projects.

Positive Factors- are factors that can have a propitious effect on construction productivity. An increase in these factors will increase productivity. For example when an employee is satisfied with the job he/ she is assigned to, he/ she tends to be more productive and pleasant to work with, as motivation levels are high.

**Table 1: Human Factors**

Capability	Knowledge & Skill	Stress	
<ol style="list-style-type: none"> <li>Physical Fitness</li> <li>Mental Health</li> <li>Competence/ Dependability</li> <li>Concentration demands</li> <li>Comprehendability</li> <li>Memory</li> <li>Judgement</li> <li>Dedication &amp; discipline</li> <li>Maturity</li> <li>Pragmaticalness</li> <li>Honesty</li> <li><b>12. Inquisitiveness</b></li> </ol>	<ol style="list-style-type: none"> <li>Experience</li> <li>Orientation to the task</li> <li>Practical training</li> <li>Education level</li> <li>Ability to instruct</li> <li>General awareness</li> <li>Anticipating outcomes</li> <li>Responsibility aptitude</li> <li>Knowledge of task risks</li> <li>Creativity</li> <li>Spoken language</li> <li>Written language</li> <li>Initiative</li> <li>Flexibility/ adaptation skills</li> <li>Assertiveness</li> <li>Problem-solving skills</li> <li>Technological awareness/ knowledge</li> </ol>	<ol style="list-style-type: none"> <li>Fatigue</li> <li>Job/ Task monotony</li> <li>Health &amp; safety hazards at work</li> <li>Uncertain elements at work</li> <li>Lacking holidays/ breaks</li> <li>Job Security</li> <li>Negative peer pressure</li> <li>Negative family/marriage effects</li> <li>Disrespected</li> <li>Smoking</li> <li>Intoxication (eg. alcohol, drugs)</li> <li>Aggression by parties involved</li> <li>Rivalry</li> <li>Sleep deprivation</li> <li>Work overload (overtime)</li> <li>Work crisis</li> <li>Time pressure to complete task</li> <li>General working environment (eg. noise, cleanliness)</li> <li>Incompetent/ improper trained workmate (s)</li> <li>Political/ administrative factors within project</li> <li>Ergonomical factors (man-machine interaction)</li> </ol>	
Motivation	Emotional	Culture	
<ol style="list-style-type: none"> <li>Attention received (acceptance)</li> <li>Colleague support</li> <li><u>Horse-play</u></li> <li><u>Boredom</u></li> <li><u>Distractions (eg. day-dreaming)</u></li> <li>Respect received</li> <li>Positive peer pressure</li> <li><b>8. Choosing work-mates</b></li> <li>Positive family/ marriage effects</li> <li>Career advancement prospects</li> <li><b>11. Learning (curve) on the job</b></li> <li><b>12. Participation in decision(s)</b></li> <li>Fairness of pay</li> <li>Team-spirit</li> <li><b>15. Task variability/ job variation</b></li> <li>Sufficiency of responsibility assigned</li> <li>Rewards</li> </ol>	<ol style="list-style-type: none"> <li><u>Greed/ selfishness</u></li> <li><u>Jealousy</u></li> <li>Job satisfaction</li> <li>Thoughts &amp; feelings</li> <li><u>Experiencing abuse/ hostility</u></li> <li><u>Fear of failure</u></li> <li>Relationship with management</li> <li><u>Complacency</u></li> <li>Confidence</li> <li>Social orientation/ openness</li> <li>Frame of mind during crisis</li> <li>Individual charisma</li> <li>Sensitivity towards colleagues/ subordinates (considerateness)</li> <li>Regularity of contact with people/ workmate(s) during job</li> <li>Sense of belonging towards company and project</li> <li>Interpersonal relationship with colleague(s)</li> <li><u>Apathy towards work (lack of emotion towards work)</u></li> <li><u>Arrogance (feeling of superiority)</u></li> </ol>	<ol style="list-style-type: none"> <li>Racism</li> <li>Perception of project risk</li> <li>Gender Issues</li> <li>Work ethics</li> <li>Loyalty</li> <li>Cultural obligations</li> <li><u>Ethnic background Issues</u></li> <li><u>Corruption</u></li> <li>Diet</li> <li>General attitude/ personality of individual</li> <li><u>Absenteeism</u></li> <li>Mind-set towards teamwork</li> <li><u>Political interests (internally &amp; externally)</u></li> <li><b>14. Ideologies on life (personal values)</b></li> </ol>	
Management	Supervision	Task	Comm & Coordination
<ol style="list-style-type: none"> <li>Commitment towards planning</li> <li>Experience</li> <li>Collective knowledge</li> <li>Qualifications</li> <li>Commitment towards project</li> <li>Leadership qualities</li> <li>Management team discipline</li> <li>Common team objectives/ goals</li> <li>Responsibility allocation</li> <li>Decision-making process</li> <li><u>Project owner interference</u></li> <li>Handling commercial pressures</li> <li>Managing project uncertainties</li> <li>Management-staff relationship</li> <li>Training &amp; team development</li> <li>Expectancy level/ vision</li> <li>Diagnosing change</li> <li><b>18. Use of power/ authority</b></li> <li>Maintaining standards</li> <li>Organisation image</li> <li><b>21. Competition (at all levels)</b></li> <li>Workforce management</li> <li>Client risks allocation</li> <li>Available resources (general)</li> <li>Project stakeholders/ owner/ user/ individual satisfaction</li> <li>Empowering staff to delegate certain duties</li> <li><b>27. Occupational health &amp; safety culture</b></li> <li>Structure/ practices and ideologies</li> </ol>	<ol style="list-style-type: none"> <li>Inspection regularity</li> <li>Work planning</li> <li>Instruction delegating clarity</li> <li>Knowledge of task</li> <li>Work-load management</li> <li>Worker/ staff discipline</li> <li>Supervisory staff competence</li> <li>Work-area control</li> <li>Managing ergonomical affects</li> <li><b>10. Control, evaluation and monitoring of performance</b></li> <li>Supervisory staff relationship with subordinates/ workers</li> </ol>	<ol style="list-style-type: none"> <li>Job description/ direction clarity</li> <li><b>2. Task complexity</b></li> <li>Matching individual with task</li> <li>Accuracy of time estimation</li> <li>Negotiation methodology</li> <li>Contract interpretation</li> <li>Ability to generate options</li> <li>Design meticulousness</li> <li>Project (team) spirit</li> <li>Budget estimated for task</li> <li>Common use of resources</li> <li>Establishing appropriate &amp; rigorous goals/ milestones</li> <li>Adequacy of essential resources (staff &amp; equipment)</li> <li>Client team functional experience and commitment</li> <li>Clearly defined accountabilities &amp; authority</li> <li>Formulation of remedial measures/ contingency plans</li> <li>Equipment/ technology selection</li> </ol>	<ol style="list-style-type: none"> <li>Communication of decisions</li> <li>Inter-racial communication</li> <li>Communication with client</li> <li>Listening (in general)</li> <li>Communicating feedback</li> <li><b>6. Asking questions</b></li> <li>Openness</li> <li>Proximity of colleagues</li> <li>Communication of standards</li> <li>Honesty/ accuracy in communicating</li> <li>Communication of objectives to all parties concerned</li> <li>Communication between group leaders</li> <li>Communicating anticipated prospective happenings</li> <li><b>14. Recordings on retrospective happenings</b></li> <li>Communication between staff &amp; management</li> <li>Communication between main office and site office</li> <li><b>17. Social activities to strengthen business relationships</b></li> <li>Coordination of information/ knowledge transfers (verbal &amp; written agreements/ messages, etc).</li> </ol>
Policies	Standards	Systems & Procedures	
<ol style="list-style-type: none"> <li><b>1. Communication policies</b></li> <li><b>2. Social-related policies</b></li> <li><b>3. Commercial related policies</b></li> <li><b>4. Bumiputera company policies</b></li> <li><b>5. Safety policies</b></li> <li><b>6. Insurance policies</b></li> <li>Policy on payments</li> </ol>	<ol style="list-style-type: none"> <li>Qualifications of staff required</li> <li>Experience of staff required</li> <li>Training standards</li> <li>Criterion for work standards</li> <li>Continuity in innovation</li> <li>Standardising/ formalisation of procedures</li> </ol>	<ol style="list-style-type: none"> <li><b>1. Record keeping</b></li> <li>Planning procedures</li> <li><b>3. Audit procedures</b></li> <li>Risk management systems</li> <li><b>5. Q/A &amp; Q/C procedures</b></li> <li><b>6. Filing of submissions</b></li> <li><b>7. Filing of drawings</b></li> <li>Work permit procedures</li> <li>Procedures on staffing &amp; resources</li> <li>Conflict/ dispute resolution procedures</li> <li><b>11. Control of main parameters: time, cost and quality.</b></li> </ol>	

Negative Factors- are factors that can have a pernicious or deleterious effect on construction productivity. An increase in these factors will decrease productivity. For example, when an employee is feeling fatigued, he/ she will be experiencing high levels of psychological and physiological strain, resulting in the inability to concentrate on the task, thus, being less productive.

**Mixed Factors**- are the third type of factor. These factors display qualities that can have advantageous to or damaging effects on construction productivity. These factors could display favourable or unfavourable effects on a project depending on the extent to which the factor is involved. Mixed factors could behave in mode A (eg. good effect) initially and then as the factor gets more influential or involved it might start behaving in mode B (eg. adverse effect).

To explain further safety policies are taken as an example. In construction projects safety policies are guidelines set by the project team to enable the implementation of a safe working environment. When safety policies are appropriately formulated and followed by participants, the project will tend to run smoothly with minimum unforeseen health and safety disruptions. This will have a positive influence on productivity.

A lack of or incomplete and even ambiguous safety policies could easily lead to an unsafe working environment as project participants will be unsure about the various safety measures or precautions that should be implemented and practised. This will eventually lower team and individual morale, which could result in the occurrence of various accidents. This consequently has a negative effect on productivity. On the contrary too many safety policies could also slowdown the progress of work, as too much time and effort will be allocated to abide to all policies. Therefore this factor is optimally effective only when it is adequately introduced or used in a project.

The factors in Table 1 (positive factors- normal, negative factors- underlined and mixed factors- bold) were assembled from a preliminary interview with construction practitioners and through a literature review (Thevendran, 2002). This led to a descriptive pilot study which was conducted to ascertain the influence placed by construction practitioners on each of the human factors listed and categorized by the researcher with regards to construction project procurement.

#### 4. Survey

Twenty construction practitioners participated in this research exercise and were selected based on their seniority and relevant experience. The participants were asked to assign values with regards to the effect of each factor towards construction productivity. The respondents were divided into two distinct categories, consultants and contractors.

The questionnaire was designed to enable respondents to answer easily and promptly as most of them experience time pressures at work. The questionnaire was made simple, clear, specific, respectful, easy to-fill-in, attractive and as short as it could possibly be. This was done to maximise the response rate, validity and reliability of the questionnaire (Zikmund, 1997). The questionnaires were distributed via post and e-mail, and were collected by hand. The methodology utilized for the selection of sample of respondents was non-random purposive sampling (Zikmund, 1997).

The respondents were asked to indicate the influence the human factors listed had on productivity. The six-point scale adopted is shown in Table 2. These were converted to a linear scale to facilitate further analysis. The introduction of a linear form of scaling will provide a continuous spectrum to the categories used in the questionnaire (Zikmund, 1997) and also enables quantitative comparisons of the results. This simplifies the process of identifying the most important factors. The conversion scores used are shown in Table 1.

An evident problem faced with the responses, is that each respondent considers his/ her own benchmark (Qambar, 1999) when assessing these factors. A ‘low’ score considered by one respondent might equate to a ‘medium’ with another. In order to ensure equal weight is given to each respondent it is necessary to normalise their scores. This is intended remove any bias related to the optimism or pessimism (Elander, 2003) of the respondent and show the relative importance of the factor. Normalizing the scores also reduces the range of scores obtained, and this evidently facilitates the ranking process as it is easier to analyse scores with a smaller range.

The normalisation index is calculated for each respondent as follows:

$$\text{Normalization Index for a Respondent} = \frac{\sum \text{avg.score.each.factor}}{\sum \text{respondent.score}} \quad \{ \text{Equation 1} \}$$

**Table 2: Conversion Scores for Scale**

Scale Adopted	Influence	Conversion Scores
V High	Influence is very high	5 points
High	Influence is high	4 points
Medium	Influence is medium	3 points
Low	Influence is low	2 points
V Low	Influence is very low	1 points
None	No influence	0 points

The total average score and total respondent score is used to calculate the normalisation index as shown in Equation 1. The standard deviation is not suitable to be used to calculate the normalisation index as it explicitly expresses the diverse opinions or spread of responses by participants on various factors. This is therefore utilized as a secondary criterion to rate the scores in all categories investigated.

## 5. Results

A general overview of the results showed that respondents tended to place higher scores for positive factors compared to negative and mixed human factors. This invariably means that to identify the most significant human factors in each category the selection criteria for positive factors has to be higher than negative and mixed factors. Positive factors with a mean above 4.0, negative factors with a mean above 3.2 and mixed factors with a mean above 3.1 were considered to be relatively significant and were utilized in a point-selection-process (Thevendran, 2002) to select the most significant human factors. The human factors selected are shown in Table 3.

**Table 3: Significant Human Factors**

Positive Factors	Negative Factors	Mixed Factors
<ol style="list-style-type: none"> <li>1. Collective management experience</li> <li>2. Supervisory staff planning skills</li> <li>3. Individual staff problem solving skills</li> <li>4. Management commitment towards planning</li> <li>5. Rewards</li> <li>6. Supervisory staff competence</li> <li>7. Individual employee work experience</li> <li>8. Management leadership qualities</li> <li>9. Job description clarity</li> <li>10. Management commitment towards project</li> </ol>	<ol style="list-style-type: none"> <li>1. Absenteeism</li> <li>2. Individual apathy towards work</li> <li>3. Corruption</li> <li>4. Individual experiencing abuse/ hostility</li> <li>5. Fatigue</li> <li>6. Health and safety hazards at work</li> <li>7. Improperly trained workmate[s]</li> <li>8. Time pressure to complete task</li> <li>9. Project owner interference</li> <li>10. Work overload</li> </ol>	<ol style="list-style-type: none"> <li>1. Systems &amp; Procedures to control main parameters.</li> <li>2. Q/A &amp; Q/C systems and procedures.</li> <li>3. Supervisory staff control, evaluation and monitoring of performance.</li> <li>4. Procedure for filling submissions.</li> <li>5. Procedures for filling drawings.</li> <li>6. Audit systems and procedures.</li> <li>7. Procedures for keeping records.</li> <li>8. Learning curve on the job.</li> <li>9. Safety policies.</li> <li>10. Participation in decisions.</li> </ol>

Note# The factors are placed in accordance to their importance.

The limits were determined by re-categorizing the scores into four different fractions. These are very high, high, medium and low. Only scores that fall in the very high category were selected. This point-selection-process considers the actual (raw data) scores, normalized scores, contractor's scores and consultant's scores where points between 1 and 10 were given for each significant factor in each category. In each category investigated the more influential the particular factor under consideration is, the higher the points given.

## 6. Conclusion

The analysis of the survey has highlighted ten factors in each distinct human factor category to be very influential in the procurement of construction projects. Although the selected factors are more influential than the factors not selected, it is imperative to realise that these factors do not act alone, but with the influence of other endogenous (human factors) and even exogenous factors. This demonstrates the systemic nature of the influence or effects of human factors. In simpler terms, for each problem or event encountered there is a whole web of factors involved.

This paper has identified the various human factors that influence construction projects, and also clearly exhibited that human factors are not limited to only *prima facie* management factors. With the large number of factors identified, the next step is to determine the true extent of its impact. A formal study is being conducted to investigate appropriate methods to assess these intangible factors and will be reported in another paper. The authors are hopeful that the findings of this study will increase the awareness of construction practitioners of the significant effects of human factors.

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