

A SYSTEMATIC APPROACH FOR THE SELECTION OF THE ARCHITECT/ENGINEER PROFESSIONAL IN CONSTRUCTION PROJECTS

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Abstract

This paper presents a model for selecting Architect/Engineer (A/E) professionals for construction projects. The model takes into account all relevant criteria considered by the owner. These criteria were identified through a comprehensive literature review, and were then clustered into seven groups, namely firm background; past experience; technical resources; management capabilities; financial stability; quality assurance; and innovation capability. The Analytic Hierarchy Process (AHP) was utilized to develop a model for A/E professional selection. This involved constructing a hierarchy of the decision, taking into account all of the identified criteria and sub-criteria and comparing the relative importance of each criterion with all other criteria. A synthesis of the results was undertaken to determine the ranking of the different professionals considered in the model. The paper is practically useful to owners interested in achieving the desired cost, quality and time in their projects.

Streszczenie

W niniejszym artykule przedstawiono model wyboru specjalistów z zakresu Architekt/Inżynier (A/E) do projektów budowlanych. Model uwzględnia wszystkie istotne kryteria brane pod uwagę przez właściciela. Kryteria te zostały określone w kompleksowym przeglądzie literatury, a następnie zostały zaszeregowane do siedmiu grup, a mianowicie: silne zaplecze; zdobyte doświadczenie; zasoby techniczne; możliwości zarządzania; stabilność finansowa; zapewnienie jakości; i zdolność innowacyjna. Analityczny proces hierarchiczny (AHP) został wykorzystany do opracowania modelu profesjonalnej selekcji A/E. Wymagało to skonstruowania hierarchii decyzji, biorąc pod uwagę wszystkie zidentyfikowane kryteria i podkryteria oraz porównując względne znaczenie każdego kryterium z wszystkimi innymi kryteriami. Podjęto syntezę wyników w celu ustalenia rankingu różnych specjalistów branż pod uwagę w modelu. Artykuł jest praktycznie użyteczny dla właścicieli zainteresowanych osiągnięciem pożądaných kosztów, jakości i czasu w swoich projektach.

Keywords: A/E professionals; A/E selection; Analytical Hierarchy Process; Construction projects; Decision model.

1. INTRODUCTION

The construction industry constitutes a major part of any country's economy. Major stakeholders in construction projects includes owners, A/E professionals, contractors, sub-contraction and material suppliers, etc. The proper selection of parties by the owner has a significant effect on the time, cost and quality of any project. Once financing has been arranged, the next step for owners is to select the Architect/Engineering (A/E) professional to agree the responsibilities of representing the owner in many services such as observing the progress of work, recommending contract compliance, interpreting contract documents, resolving disputes, modifying the contract documents, if necessary, reviewing the submittals, and performing the inspections of the work [1]. While the fees of the A/E professional for the services provided are relatively low compared to the total costs of construction, the services provided by the A/E professional have a significant effect on the time, cost and quality of the project. Currently, there are around 3435 established A/E firms in different regions of Saudi Arabia [2]. These firms provide a wide spectrum of services, including basic design services, construction management, quantity surveys, feasibility studies, budgeting, site selection and analysis, value engineering, marketing studies, environmental studies and life cycle costing [3].

There are multiple factors that should be considered in selecting the appropriate A/E professional for any project. Moreover, there are currently several methods for selecting A/Es. These include direct selection method, competitive fee selection method, design competition method and comparative selection method [3]. Nevertheless, using any of these methods might not necessarily be in the best advantage of the owner. Therefore, there is a need to introduce a formalized quantitative method, which accounts for all the criteria and sub-criteria that are considered to be important by the owner. The objective of this paper is to present the development of a systematic approach for the selection of A/E professionals for construction projects. This paper is of practical value to owners and contractors worldwide, as the selection of the appropriate A/E professional would result in better time, cost and quality of their projects.

2. SELECTION METHODS OF A/E PROFESSIONALS

There are several methods that are currently being used by private and public owners for the selection of A/E professionals in construction projects. These methods are direct selection method, competitive fee selection method, design competition method, and comparative selection method.

- **Direct selection method:** the owner selects the A/E professional based on personal knowledge, previous experience and recommendation of former clients [4, 5] The main disadvantage of this subjective method is that small A/Es and newly established firms may encounter less demand for their services.
- **Competitive fee selection method:** the owner selects the A/E professional based on the amount of fee submitted by the A/E professional for needed services [6, 7]. The main disadvantage of this method is that it requires a clear definition of the needed services, which the owner sometimes can not provide. Further, the owner could receive work at poor quality [8].
- **Design competition method:** the method requires a knowledgeable owner who can properly evaluate design. The main disadvantage of this method is that the owner could end up selecting an incompetent and an inexperienced A/E which would result in costly design errors [9].
- **Comparative selection method:** the owner compare the A/Es on the basis of several weight-assigned criteria depending on the type and size of the project. These criteria include the A/E organization, resumes of key personnel, work plan, manpower plan compared to available resources, identification and procurement capabilities, CAD capabilities, project control capabilities and safety and loss prevention program. However, it could be that one criterion such as "manpower plan compared to available resources" could disqualify the A/E if the firm does not fulfil this requirement. Although, this method is better the other three selection methods, there is an element of subjectivity in the assignments of weights to the criteria [10].

Owing to the fact that proper selection of A/E professionals by owners is of prime importance to the success of their projects, this paper presents a systematic approach for the selection of A/E professionals, taking into account all the main criteria and sub-criteria of making the decision for the selection of the A/E. The proposed approach is based on the Analytic Hierarchy

Process (AHP), which can be used for arriving at decisions in various contexts of decision making.

3. PREVIOUS STUDIES

Several studies on the selection of A/E were conducted in several countries. These studies demonstrated several approaches to the selection process by clients. Moore [11] opposed the selection of A/E on the basis of design fee alone. Rather, the selection should be based on the professional knowledge of the A/E, experience and understanding of the owner's needs. Kasma [12] indicated that A/Es are selected based on the design fee rather than on qualification. A selection procedure, consisting of six steps, was proposed for the effective selection of A/Es. The procedures involve soliciting firms' qualifications, organizing a job explanation meeting, receiving proposals, short-listing firms for interview, conducting interviews, negotiation with the selected firm. Potter and Sanvido [13] developed a model for A/E prequalification and selection. The model included several constraints, namely economic, political, technological, corporate policy, labor and personnel and legal aspects. Al Musallami and Assaf [3] indicated that 66% of public owners in Saudi Arabia use the comparative selection method, which is considered at that time to be the fairest selection approach to owners and A/Es. Al-Sobiei et al. [14] indicated that the majority of claims in construction projects, resulting from owners' dissatisfaction, ambiguous contract documents and design errors, are attributed to the improper selection of A/Es. Assaf et al. [15] indicated that improper selection of A/Es results in faulty design, which ultimately impacts negatively on the maintenance costs of projects, and service life of projects. Al-Besher [8] surveyed 30 public sector organizations and 30 consultants in Saudi Arabia to identify the major selection criteria of A/E. The study concluded that the major selection criteria are "work experience", "project management", "capability", "staff and qualification", "quality performance", "quality control", "references" and "firm capacity". Cheung et al. [10] developed a multi-criteria evaluation model for the selection of A/E consultants in Hong Kong. The selection criteria and their relative importance were identified through a survey of 10 different organizations in the United States involved in A/E consultancies. Then, these criteria's were used in the development of an AHP model for A/E selection. Ling [16] developed a conceptual model for the selection of architects by project managers in Singapore. There were a total of 25 attributes which

were selected for survey among the developers who hires consultants. The study concluded that the selection of the A/E depends primarily on three attributes. These attributes are "the A/E's problem solving ability and project approach", "A/E's speed in producing design drawings", and "the A/E's level of enthusiasm in tackling a difficult assignment". Ling [17] developed a multi-decision making model for the selection of architects by project managers. The model included 40 attributes for the selection of the architect. The study concluded that 34 attributes are important. However, the most important attributes are "good knowledge of economical designs and constructability", "producing designs which have functional quality", "gaining adequate job experience", and "producing design drawings and obtaining statutory approvals speedily". Ng and Chow [7] developed a framework to determine the important criteria for the pre-selection of consultants in Hong Kong. A multi-criteria model was then developed to score the capabilities of consultants. Consultants with acceptable scores were the only ones invited to submit bids for projects. Abdulwahab [18] conducted a study to evaluate the performance of consultants in Saudi Arabia. The study identified 40 criteria, and concluded that the most important criteria are "quality of design", "compliance to client's requirements", "quality of bid documents", "recruitment, supervision and administration of site staff", and "supervision of contractors". Sporrang [19] conducted a survey on Swedish municipalities to determine the method of selecting A/Es. The study revealed that municipalities select A/Es mostly on basis of design fee. The survey showed that municipalities' managers are generally satisfied with this practice.

4. CRITERIA FOR THE SELECTION OF A/E PROFESSIONAL

The criteria for the selection of A/E professional were derived from the literature review of past studies. The criteria were grouped into seven major categories. These categories are described as follows:

4.1. Firm Background

Firm background [8, 10, 20] includes:

- **Reputation and references:** reputation is the most significant indicator on the firm background. This can usually be accomplished by checking references of the firm background and the key individuals of the firm.

- **Compliance with requests:** the degree of willingness of the A/E to comply with the requests of the owner in changes and modifications of the design documents in previous projects is of high importance to the owner for the completion of the project.
- **Service fee:** the method of compensating the A/E in previous projects is important to the owner to consider in the selection process of the A/E. The satisfaction of the owner in dealing with the A/E in terms of the method and amount of payment is also important in the selection of the A/E.
- **Location of offices:** the location of the main office of the A/E in relation to the owner's location becomes important in dealing with the demand and promptness of completing the work.
- **Current engagements:** the A/E current workload would have an impact on the completion of additional new work. The owner should obtain first-hand information on the amount of work that the A/E is currently performing.

4.2. Past Experience

Past experience reveals the true strength of the A/E professional. It defines the capability of the firm and their track record. The sub-criteria to consider by the owner [3, 10, 16] include:

- **Type of projects completed:** past experience in the same line of work is necessary to ensure that the A/E is capable of completing the new work.
- **Size of projects completed:** past experience in the same size of the project is necessary to ensure that the A/E is capable of completing the new project.
- **Years in business:** firms that have long experience in the same type and size of work are much more competent to undertake and complete new projects.
- **Earlier relevant projects:** A/E professionals who have similar relevant projects will be able to deliver work on new projects without delays and conflicts.
- **Specialization:** specialization in the line of the propose work becomes essential to the owner to complete the project with efficiency and quality.

4.3. Technical Resources

Technical resources [17, 21] include:

- **Total number of technical and administrative staff:** the number of technical and administrative staff is

critical to the success or failure of the firm. Adequate number of technical staff will provide the required knowledge and skills to accomplish the assigned tasks. Adequate number of administrative staff will ensure proper and prompt administration of the firm.

- **Quality and experience of key personnel:** Academic qualification and professional certification of key personnel in any firm reflect the image and reputation of that firm. Clients will have more confidence in selecting A/E firms that have acquired the necessary background knowledge for the firm business.
- **Design capability:** the quality of the design sets the standards for the project. Proper design would positively reflect on the life cycle cost of the project.
- **Available equipment and software:** the availability of needed software and hardware would enable the staff to perform their technical and administrative tasks effectively.
- **Cost effectiveness:** plans and specifications provided by the A/E would have a direct effect on the ultimate cost of the project.

4.4. Management Capabilities

Management capabilities [19, 22, 23, 24] include:

- **Number and experience of management staff:** effective management and leadership of the firm provide motivation to accomplish tasks efficiently.
- **Maintaining relations with clients:** maintaining relations with clients provides means for executing the projects in hand, and securing more projects in the future.
- **Time management:** clients require delivery of projects with specified time-frames. Proper use of time management techniques such as bar-chart and scheduling networks would assure completion of projects on time.
- **Time overrun in previous projects:** Delayed projects would reflect negatively on the A/E firm's reputation and selection for future projects.
- **Cost overrun in previous projects:** Projects that were under-estimated by the A/E would cause financial difficulties to the client. Such difficulties would limit the selection opportunities for future projects.

4.5. Financial Stability

Financial stability [3, 14, 17] include:

- **Economic constrain or amount of claims from pre-**

vious projects: claims resulting from A/E professional work affect the selection of the A/E for future projects. These claims could arise from safety and safety standards, pollution and emission standards, fuel efficiency requirement and price controls.

- **Amount and duration of professional indemnity insurance:** the amount and duration of professional indemnity insurance provide assurance to clients in case of future claims on projects.

4.6. Quality Assurance

Quality assurance [22, 25] includes:

- **Quality of work:** quality of work depends on the level of professionalism, time management, teamwork effectiveness, knowledge and reputation.
- **Quality scheme:** pertains to the uniqueness of a particular aspect in the design of the project.

4.7. Innovative Capabilities

Innovative capabilities [17, 19, 23] include:

- **The methodology followed for delivering innovative work:** the consulting methodology is an approach through skillful consultants use their special knowledge and expertise to the benefit of their clients.
- **Green approach:** involves life cycle costing studies and sustainability of the project. Such studies provide consultants with an edge for selection by clients who seek green projects.
- **Pollution control:** projects resulting in controlling air, water and noise pollution would positively reflect on the selection of their consults for future projects.
- **Awards received by the firm:** firms that receive recognition for their projects stand a high chance for being reselected in future projects.

5. METHODS FOR MULTI-CRITERIA ANALYSIS

A/E professionals' selection is generally considered as a multi-criteria decision problem that depends on project uncertainty and judgment of decision makers. Many multi-criteria decision making (MCDM) methods depend on different assessment tools. The multi-criteria evaluation of A/E professionals may include utility levels, graph theory, matrix methods, or fuzzy set theory [26, 27, 28, 29, 30]. MCDM criteria for the selection of A/E professional can be measured on a

qualitative or quantitative basis. In general, quantitative methods are more mathematically sophisticated than qualitative methods. As an example, a mathematical programming model is used as a method to select the best project risk response strategies [31]. In such models, interpretation and validation of the results may require a mathematics background. This can be seen as a limitation of quantitative methods, although it allows for objective evaluation of contractors. MCDM qualitative methods are more prevalent for use in practice due to their simplicity and effectiveness. A brief survey of some of the most commonly used MCDM methods is provided, in order to increase complexity and power:

5.1. Alternatives-Attributes Score Card

A score card is a matrix of alternatives versus attributes, together with numbers or other symbols to represent the outcome expected for each alternative with respect to each attribute. Ease of interpretation of the scorecard, to facilitate decision making, can be obtained by such devices as symbols and colors for "best" and "worst" alternatives for each attribute [32].

5.2. Ordinal Scaling

An ordinal scaling is simply a ranking of criteria in order of preference. Before attributes are weighted (or alternatives are evaluated), it is often desired to rank them in order of decreasing preference. This might be done by presenting the decision maker with a list of attributes (or alternatives) and asking him or her to rank them in order of preference. In general, if there are N factors, then $N(N - 1)/2$ pairs must be judged. In general, ordinal scaling is criticized for inconsistency [32].

5.3. Weighting Factors

Many numerical formula methods for assigning weights that exist are easy to use, but they are generally less defensible than direct assignment of weights on the basis of preference comparisons among criteria. In general, the weights can be ordered, but not limited, as uniform or equal weights, rank sum weights, or rank reciprocal weights [32]. Other forms of the weighting factors can be found in the literature [33].

5.4. Weighted Evaluation of Alternatives

Once weights have been assigned to attributes, the

next step is to assign numerical values regarding the degree to which each alternative satisfies each attribute. This is generally a difficult judgment task, using an arbitrary scale of, say, between 0 to 10 or a to 1,000 to reflect relative evaluations for each alternative and each attribute.

5.5. Analytic Hierarchy Process (AHP)

The analytic hierarchy process (AHP) was developed and documented primarily by Thomas Saaty. Applications of this methodology have been reported in numerous fields, such as transportation planning, portfolio selection, corporate planning, marketing. Pair wise comparisons of the elements (usually, alternatives and attributes) can be established by using a scale indicating the strength with which one element dominates another with respect to a higher-level element. Finally, a consistency test should be done for the pairwise consistency [34].

Nevertheless, more complex methods can be found in the literature. However, due to their high level of complexity, their use would be limited for the selection of the A/E professionals. Examples of these methods include technique for order of preference by similarity to ideal solution [35, 36]; elimination and choice expressing reality [37] and preference ranking organization method [37].

6. DEVELOPMENT OF A MULTI-CRITERIA DECISION MAKING MODEL

The Analytical Hierarchy Process (AHP) is a multi-criteria decision making model, which uses the relative weighting method to rank various options. The options in this research are the several A/E professionals that the owner can select from. In this process, scores and weights are assigned based on the relative importance of any particular criteria and sub-criteria. The utilization of the AHP process for the selection of A/E professionals is convenient because it allows the decision maker to make an informed and consistent decision. The decision maker can add or subtract criteria based on the requirements of the owner, as different owners may need to customize the model to suite their requirements, while maintaining consistency and efficiency.

The AHP process was developed by Saaty [34]. It is based on the system of relative weights. In this method, the respondent, being the owner in this research, is asked to determine the relative importance of each criterion relative to the other criteria.

The respondent can use a scale of 1 to 9 to determine the relative importance of each criterion. Table 1 shows the scale of relative importance weights that could be assigned to each of the criteria.

Table 1.
The scale of relative importance weights of a certain criterion

Terms of Importance	Weights
Equally important	1
Moderately more important	3
Strongly more important	5
Very strongly more important	7
Overwhelmingly more important	9

Seven main criteria and 28 sub-criteria were identified to potentially affect the A/E selection process. All the criteria used in development of model were assessed through a questionnaire survey. The survey was conducted in public and private sectors. Two private owners in each sector were asked to determine the relative importance of each criteria and sub-criteria. The private owners are major developers in the Eastern Province of Saudi Arabia, who execute multiple projects over the magnitude of 20 million Saudi Riyals. These private owners involve several A/E firms in the production of the design documents as well as the supervision of these projects. The public owners represent two large organizations involved in several construction projects. These owners also select A/E professionals for the design and supervision of their projects. Three long established consultants, located at the Eastern Province of Saudi Arabia, who submitted technical proposals to both private and public owners were selected. Representatives of both private and public owners were requested to rate the relative importance of each criteria and sub-criteria. The technical proposals include all the relevant information about the A/E firms.

Expert Choice software [38] was used to determine the priority of each criterion and sub-criteria and the overall priority for the selection of A/E professionals for both public and private owners. Table 2 shows the relative importance of the main criteria and sub-criteria for the selection of the A/E professionals from the perspectives of public and private owners of construction projects in Saudi Arabia.

Table 2.
The relative importance of the main criteria and sub criteria for selection of A/E professionals

Criteria	Priority for Public Owners	Priority for Private Owners
Firm Background	0.279	0.214
• Reputation and references	0.246	0.475
• Compliance with requests	0.087	0.302
• Service fee	0.515	0.114
• Location of office	0.037	0.049
• Current engagements	0.115	0.060
• Past Experience	0.225	0.141
• Type of projects completed	0.154	0.237
• Size of projects completed	0.264	0.487
• Years in business	0.461	0.051
• Earlier relevant projects	0.058	0.153
• Specialization	0.063	0.073
Technical Resources	0.286	0.393
• Total number of technical and administrative staff	0.090	0.279
• Quality and experience of key personnel	0.254	0.163
• Design capability	0.467	0.444
• Available equipment and software	0.038	0.034
• Cost effectiveness	0.151	0.079
Management Capabilities	0.026	0.022
• Number and experience of management staff	0.427	0.493
• Maintaining relations with clients	0.036	0.055
• Time management	0.260	0.049
• Time overrun in previous projects	0.179	0.157
• Cost overrun in previous projects	0.096	0.247
Financial Stability	0.092	0.126
• Economic constrains or amount of claims from previous projects	0.143	0.143
• Amount and duration of professional indemnity insurance	0.857	0.857
Quality Assurance	0.056	0.063
• Quality of work	0.875	0.167
• Quality scheme	0.125	0.833
Innovation Capability	0.036	0.039
• The methodology followed for developing innovative work	0.610	0.658
• Green approach	0.192	0.048
• Pollution control	0.148	0.212
• Awards received by the firm	0.050	0.083

Table 3.
The overall priority for each of the three compared A/E professionals in public and private construction projects

Alternative A/E Professionals	Overall Priority for Public Owners	Overall Priority for Private Owners
A/E Professional no. 1	0.368	0.290
A/E Professional no. 2	0.198	0.454
A/E Professional no. 3	0.434	0.256

Table 3 shows the overall priority for each of the three compared consultants in public and private construction projects.

7. DATA ANALYSIS AND DISCUSSION

The AHP methodology served to determine the relative importance of each main criterion from the perspective of both public and private owners of construction projects. The ranks and weights of each of the criteria were also determined as illustrated in Table 4. It could be observed that the ranking of the criteria's level of importance from the perspective of both public and private sector owner is the same. Also, it could be observed that the three main criteria "technical resource", "firm background" and "past experience" constitute 79% and 75% from the perspectives of the public and private owners, respectively.

The analysis of the main criteria and their sub-criteria in terms of relative importance shows the following:

- **Firm background:** public owners consider "service fee" to be the most important criterion, while the criterion "reputation and references" is the most important criterion to private owners.
- **Past experience:** the "years in business" is the most important criterion for public owners, while the "size of projects completed" is the most important criterion for private owners.

- **Technical resource:** it could be ascertained that the "design capability" is the most important criterion for both public and private owners of construction projects.
- **Management capabilities:** the "total number and experience of management staff" is the most important criterion for both public and private owners.
- **Financial stability:** both public and private owner agree that the "amount and duration of professional indemnity insurance" is the most important criterion in this category.
- **Quality assurance:** the most important criterion is the "quality of work" with respect to public owners, while the "quality scheme" is the most important criterion to the private owners in this category.
- **Innovation capability:** both public and private owners agree that the "methodology followed for developing innovative work" is the most important criterion in this category.

The results from the analysis illustrate that the "management capabilities" criteria are found to be the least important among all other criteria. This is mainly attributed to the fact that the firms surveyed emphasized more on other criteria because of their nature of business. If this would have been the case of project management consultancy, "management capabilities" criteria would have received more weight than other criteria. The firms surveyed for this study provide technical consultancies to their clients

Table 4.
The ranks and weights of each of the criteria

Criteria	Public Owner Sector		Private Owner Sector	
	Importance (%)	Rank	Importance (%)	Rank
Technical resource	28.6	1	39.3	1
Firm background	27.9	2	21.7	2
Past experience	22.5	3	14.1	3
Financial stability	9.2	4	12.6	4
Quality assurance	5.6	5	6.3	5
Innovation capability	3.6	6	3.9	6
Management capabilities	2.6	7	2.2	7

and are not directly involved with project management. Therefore, it could be observed that criteria such as “technical resources”, “firm background” are given more weights than “management capabilities”. Furthermore, sub-criteria such as “total number and experience of the management staff”, “maintaining relations with clients” and “time management” in the “management capabilities” criteria could also be related to other sub-criteria such “reputation and references”, “size of projects completed” and “type of projects completed” in other categories. As a result of the inter-dependencies between the aforementioned sub-criteria, their weights get distributed.

Other sub-criteria within the “management capabilities” criteria such as “time overrun in previous projects” and “cost overrun in previous projects” could be related to “type of projects completed” and “size of projects completed”. Furthermore, with engineering consultants, clients sign professional indemnity insurance before the start of their projects to cover any potential losses.

8. CONCLUSIONS

The AHP methodology was used to select the most suitable A/E professional based on the requirements of the public and private owners. A set of criteria was identified and under each main criterion, sub-criteria were also identified. These criteria were evaluated through a questionnaire survey of public and private owners of construction projects in the Eastern Province of Saudi Arabia. Then, the most suitable A/E professional was selected. The most important criteria were found to be the “technical resource”, “firm background” and “past experience”. From the perspective of public owners, the most important sub-criteria are “service fee”, “years in business”, “design”, “number and experience of management staff”, “amount and duration of professional indemnity insurance”, “quality of work”, and “methodology”. From the perspective of private owners, the most important sub-criteria are “reputation and reference”, “size of project done”, “design”, “number and experience of management staff”, “amount and duration of indemnity insurance”, “quality scheme”, and “methodology”. The developed model is valid for a wide range of consultancies involved in different specialties. The model can be tailored to meet the requirements of the business to achieve the desired objectives of the client for the selection of the required consultant. Although the proposed model was carried out in the Eastern Province of Saudi

Arabia, it could be used for selection of A/E professionals in other parts of the world. It is worth noting that the criteria and sub-criteria used in the model could be different from one country to another. However, the application of the model could be used on the global basis.

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