young cities
Developing Urban Energy Efficiency
Tehrān-Karaj

06

Young Cities Research Paper Series, Volume 06

Construction Competencies and Building Quality

Case Study Results

Bernd Mahrin, Johannes Meyser (Eds.)

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Edited by Bernd Mahrin, Johannes Meyser

BHRC

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Young Cities Research Paper Series
Editors: Rudolf Schäfer, Farshad Nasrollahi, Holger Ohlenburg, Cornelia Saalmann, Florian Stellmacher

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Prof. Dr. Johannes Meyser and Bernd Mahrin

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Preface

The interdisciplinary German-Iranian Young Cities research project was financially funded by the German Federal Ministry of Education and Research (BMBF) as well as the Iranian Ministry of Roads & Urban Development (MRUD) (former Ministry of Housing and Urban Development, MHUD). Young Cities is a cooperation project between Technische Universität Berlin (TU Berlin) and the Road, Housing & Urban Development Research Center of Iran (former Building and Housing Research Center, BHRC). The Young Cities project is focused on energy efficiency and belongs to a worldwide program of nine research projects that are funded by the German BMBF. The other projects are located in India, China, Vietnam, South Africa, Ethiopia, Morocco and Peru.

This sixth volume of the Young Cities Research Paper series examines the interdependency between the energy efficiency of buildings, the quality of construction, and the level of workmanship. The results are based on multiple case studies at construction sites in the Tehran-Karaj region, the work of expert, interviews with Hashtgerd residents, and secondary analyses of Iranian earthquake studies. The research activities took place from 2009 to 2012.

At first glance, the research seems to show that the current construction practice in Iran is dominated by quality deficiencies and worker's incompetence. However, this is not the case, and the intention has never been to shed a bad light on the state of Iranian construction. Given the structural deficits in construction vocational training, a high rate of temporary employment, the high percentage of unskilled workers, and a few more aspects, the Iranian and German project partners agreed to attempt to identify the most urgent needs in construction qualification and to develop adapted training concepts. The nature of the project made it unavoidable that the focus be on apparent problems. This is done with the greatest respect towards Iranian construction practitioners, who must build more than one million housing units per year to meet the rapidly growing demand.

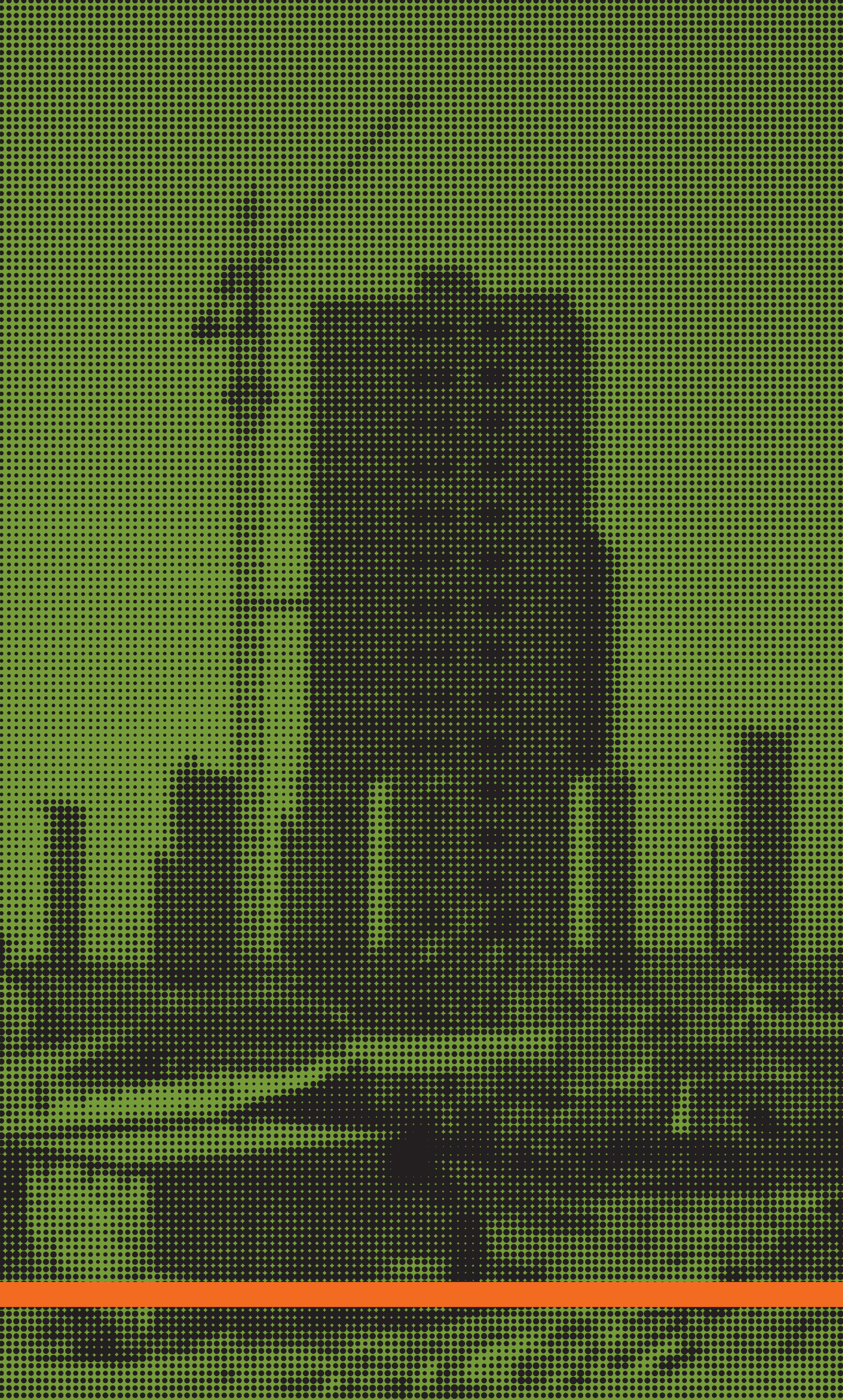
The main part of this book consists of a classification of damage cases in the following fields: concrete work, energy efficient construction, welding, site arrangement and installation work. The project partners identified these fields as the most important ones, and although research could contribute to further subjects, it is restricted by available resources.

This volume of the Young Cities Research Paper series has been conceived as a combination academic study and manual to evaluate the quality of workmanship and results at construction sites. It is not intended to substitute technical books, but rather to identify problematic situations, clarify possible subsequent damages and reconstruction options, and to concisely describe proper execution. Thus, the book may help avoid further mistakes in the future and make clear the qualification needs, as well as to recognize and correct current shortcomings as much as possible.

Although the damage cases explored here refer to a limited set of construction sites, they stand as industry-wide examples of Iranian mass residential construction, a fact confirmed by insiders. Further, they can be seen as representing similar situations in many other countries of the Middle-East-Northern-Africa region. Given this, the authors hope that this book may be useful in analyzing qualification needs and setting up adequate practical vocational training courses wherever occasion demands.

Prof. Dr. Johannes Meyser

I
Background and Initial Situation



Background and Initial Situation

Bernd Mahrin

This documentation concludes the “Case Studies” work package of the Capacity Development dimension within the Young Cities Project. Although starting from a quite fragmentary data base, this work explores meaningful usable knowledge about typical situations at Iranian construction sites, about the worker’s qualification levels, and about the common working methods of Iranian construction site staff.

The study presents the results of different investigations from 2008 to 2012. These were carried out and interpreted by construction professionals from the Vocational Advancement Service of the Berlin-Brandenburg Construction Industry Association (BFW-BB) along with scientists from the Institute of Vocational Education at the Technische Universität Berlin (IBBA, TU Berlin). The study was supported by the Iranian Building and Housing Research Center (BHRC).

This analytic work is a proper basis for developing and proving further vocational training activities which are intended to be realized by means of the action research in the framework of the Young Cities Project. This will include a road map for the systematic training of instructors and a concept for a multi-functional vocational training center called LIFE Center, as well as the development of didactical media and the planning of mobile learning units close to construction sites (Mahrin 2012 b).

A variety of information sources and materials were used for this research work. The results were validated by construction site visitations and through interviews with Iranian scientists and construction practice experts. In particular the following methods and means were used:

- analysis of available literature, including “gray” literature, such as internal reports from responsible institutions (e.g. Saidi 2003),
- analysis of online sources (e.g. TVTO 2010),
- inspections of various Iranian construction sites and talks with employees of the construction companies,
- interviews with Iranian experts in Iran and in Germany,
- expert workshops in Iran and in Germany,
- qualification workshops for Iranian professionals in Hashtgerd at the New Quality Building’s construction site,
- visit to a Tehran trade fair at and talks with exhibiting companies,
- visits to Iranian vocational training centers and interviews with responsible staff members.

The Iranian and the German partners of the Young Cities Project agree that the vocational training in Iran's construction sector needs to be improved, in both quantity and quality, in order to reach the ambitious governmental goals for the residential construction sector. In the past few years, the various responsible ministries (construction, labor, social affairs and education) have already implemented a number of individual activities. While a good start, these approaches need to be adapted and harmonized. Many discussions ended in the realization that all involved parties are aware of the needs and want to create coordinated solutions (see Majedi Ardakani 2004).

The political purpose of creating and expanding vocational training structures and concrete qualification measures in the construction sector is led by the necessity to enhance residential construction in quality and quantity in order to satisfy the rapidly rising demand for housing space.

Analyses of the construction situation in Iran by Iranian experts, combined with evaluation of structural damages, brought up additional reasons to strengthen vocational training activities in the construction sector. Unquestionably there is a massive need for action, although the Iranian and German associates have differing opinions about the most important target groups for vocational education and qualification measures. The German side is suggesting a concentration of efforts on the practical qualifications of construction workers, site foremen and general foremen. However, the Iranian side sets the focus on the qualification of engineers regarding new building technologies and sophisticated materials. They also support worker's qualifications, but only secondarily. The engineers themselves expect more theoretical lessons than practical training.

Public statements of the BHRC-President, Prof. Dr. Seyed Mahmoud Fatemi Aghda, indicate that the optimization of construction methods and the improvement of construction quality are the main focus of Iran's leading construction research center. In talks within the context of the Young Cities Project he explicitly stated this. He pointed out that the BHRC and the ministry both attach great importance to the development of vocational training. Some statements of Prof. Fatemi Aghda are summarized below:

> *According the monthly report of the Magazine "Economy of Iran" (No. 64, July 2004) the Iranian residential market is producing more than nine apartments per one thousand townspeople annually. The amount of investments for residential construction of the past years was between thirty and fifty percent of all] investments. The construction industry stays one of the strongest profitable markets, despite much fluctuation in the market and in the construction of apartments between 2004 and today.*
>
> *The demand for apartment units is around 1.5 Million each year. According to the statistics of the Central Bank, the maximum demand for housing was in 2011 and 2012.*
>
> *The rising and declining range of residential construction in certain periods of time is obviously a reaction to political, economic,*

and cultural problems. The request for homes rose steadily during the last years. According to the magazine "Fars and Business Monitor" building projects will still have a good run for investors. The achievable return on investment for residential construction is reaching a factor of 2.3.

In these reports, the growth of the Iranian economy was estimated at 2.4% for 2009, meanwhile the annual growth of the construction sector is predicted to be 12.2% by 2013. [Annotation of the editor: Due to the extensive construction activities, construction costs are decreasing, and apartments constructed earlier are therefore very hard to sell. If they are sold, it is at a substantial loss. This is why there are a lot of empty buildings, which are ruinous for small and medium-sized investors and do not contribute to covering the high demand].

The part of standardized construction which uses industrial prefabrication is only three percent of the whole construction volume in Iran. Concrete, steel, bricks and chalkstone are the most common, all of which have a high consumption of energy during the production process. Regarding the rapidly rising energy costs in Iran and the whole world, there is no alternative to energy efficient construction. For example, it would not be rational to turn millions of tons of clay into bricks. Universities still teach traditional construction, improvement of the education methods and teaching materials used at universities and institutions is absolutely necessary.

The German professionals in the Young Cities Project largely disagree with the common assumption that increasing the use of industrial construction methods in Iran would reduce costs and improve energy efficiency. Only in a few special cases could this lead to appreciable positive results. Instead of turning away from traditional construction methods, the German experts suggest keeping and optimizing historically proven construction techniques and traditions, and further, to complement them by adapting new materials and technologies.

Many BHRC-experts do agree with this strategy because around 75% of the construction sites in Iran are private sites where traditional construction already dominates. A fruitful scientific discourse will push both sides' knowledge and experience. Technologies, materials, execution methods and modern project management are tested in pilot projects and, as much as possible, followed with qualification activities (Rückert et al. 2011).

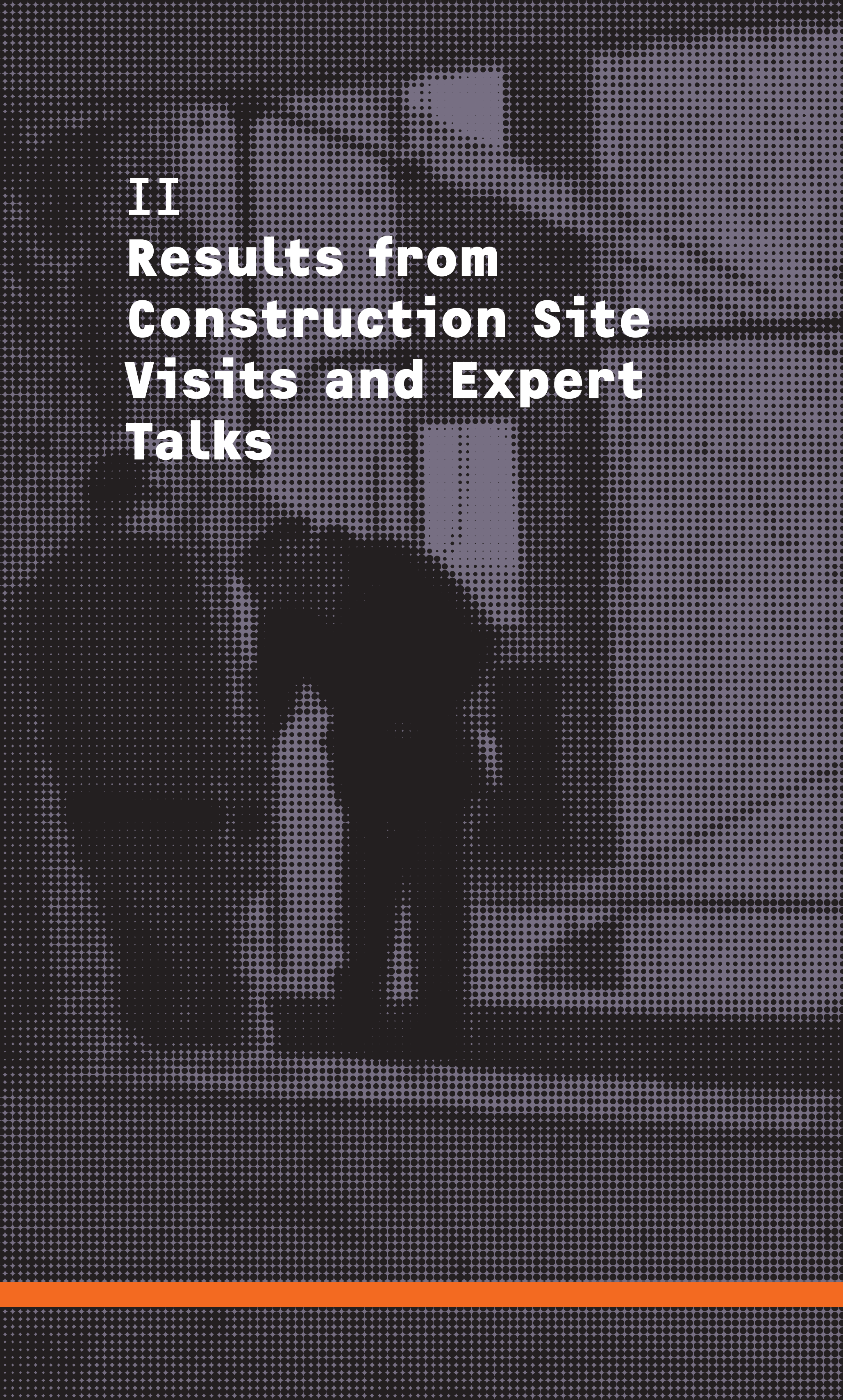
Approaches and materials to improve the vocational training in Iran's construction sector are created for the Young Cities project by considering the following studies' results. Video based digital online media and picture based printed instruction sheets exemplify proper workmanship (Mahrin 2012 a). These media will soon be tested in the Tehran/Hashtgerd region. The final concepts and products are created in such a way as to be easily transferrable to other regions.

This study cannot give a complete realistic picture of the situation at Iranian construction sites, and such was not the purpose of the research work. The aim was to identify typical problems, critical situations, and damages caused by qualification deficits and highlight a need for action. Some positive results of the visits and conversations were not included, since they do not directly lead to suggestions for improvement. However, simply focusing on our monitoring results might give an overly negative impression of Iranian construction sites. This is not our intention, but is unfortunately unavoidable given the research and documentation design.

The majority of the identified problems and damages can be directly traced to improper workmanship, and thus to a lack of worker competencies. Another major problem is inappropriate design, stemming from inadequate practical experience of the engineers and architects. The more future qualification courses can take the common situation of construction sites into consideration the greater their ability to influence quality and energy efficiency strongly and sustainably.

The editors and authors sincerely thank all dialogue partners and supporters in Iran and Germany for their dedicated contributions and their frankness. Hopefully this rich collection of starting points will provide valuable insights into the improvement of vocational training in the field of construction.

II
Results from Construction Site Visits and Expert Talks



Results of Construction Site Visits and Expert Talks

Karen Schmidt | Bernd Mahrin

Participants

Karen Schmidt, Siegfried Zitzmann (both Berufsförderungswerk Berlin-Brandenburg e.V.)
Nadia Poor Rahim (Technische Universität Berlin)
Hassan Rafii (Building and Housing Research Center, Tehran)
Masoud Rezaei Badafshani (on behalf of Technische Universität Berlin)
Bernd Mahrin (Technische Universität Berlin)

Preface

Throughout the project's duration, members of the Young Cities Capacity Development Dimension staff traveled to Iran several times to obtain first-hand information on typical Iranian construction sites: the materials and technologies used, as well as the general professional qualification level of construction site personnel in Iran. The following fundamental questions were the main focus of the construction site visits and personal discussions:

- What are the preferred construction types/techniques in Iran?
- What is the general level of quality in construction?
- Where are problems most likely to occur in the execution of construction work?
- Where can qualification needs be identified?

The construction site visits covered a large area in and around Tehran, including Karaj, Hashtgerd, and Andisheh as well as the city of Isfahan. The observations and experiences noted here cannot serve as a basis for a comprehensive assessment of the situation in Iran as a whole. To do so would require expanding the case studies to include other parts of the country. However, many statements made by Iranian construction experts and others with an in-depth knowledge of Iran, indicate that the situation is comparable across the country.

A total of six individual building sites were visited, ranging from the large-scale construction of entire residential quarters, to mid-sized projects, and one small, private construction site. In addition, observers recorded an excursion through Tehran with explanations given by engineer Mr. Hassan Rafii (BHRC), commentary which is included in this summary.

To ensure adequate data collection and documentation of the site inspections and the talks with construction experts and on-site personnel, observers used combined inspection checklists/interview guidelines created specifically for this purpose (see Appendix). Accordingly, this is a qualitative examination with partially standardized interviews. In addition, scenarios encountered at the construction sites, as well as construction defects and structural damage, have been documented photographically. The corresponding cases of damage, or problematic situations, have been incorporated into the Case Study Results presented in the following.

Findings

Preferred Techniques and Materials

Since earthquake resistance is a prime consideration in the planning and constructing of buildings in Iran, preference is given to light-weight construction. The supporting structure usually follows one of two predominant design variants: a steel skeleton filled in with brick masonry, or reinforced concrete skeleton structures walled up with brickwork. At some construction sites, walls and ceilings are also made of reinforced concrete, as in the new residential quarter in Andisheh.

The ceilings of older houses consist mostly of cambered brickwork. At newer sites (e.g. Hashtgerd) observers also found filigree reinforced concrete carrier elements resting on the supporting structure, with insulation panels inserted and then covered with concrete.

Construction and installation of floor screed on raw floors is still done by very traditional methods, as described in the chapter *Classification of the Cases of Damage Discovered at Construction Site Visits*.

Traditional building techniques in Iran generally did not incorporate load-bearing walls. The supporting structures – various types of stud framing – were filled in with brick masonry. Thermal insulation requirements, i.e. minimizing heat loss, were obviously not a major consideration. This may change, however, as reworking of building regulations, e.g. Code 19, appears imminent. Yet, it is unclear to what extent these new regulations will be implemented, given that neither the construction process nor the end results are systematically or comprehensively monitored.

Wall thicknesses range from 11 to approximately 20 cm for exterior walls and from 11 to 18 cm for interior walls. Sound insulation requirements for dividing walls and floors/ceilings in residential units are not common. If such specifications do exist, they are thoroughly inadequate and/or commonly disregarded.

In the shell construction phase, metal frames for doors and windows are installed. These also serve as lintel overlapping. This gives rise to stability issues and – in the case of exterior walls – creates thermal bridges.

As seen in many completed buildings, most windows do not have sills. Wherever there are window sills, overhang is insufficient and they lack drip edges.

Façades are usually either plastered or covered with tiles and panels. Insulation materials are very rarely used in exterior walls. If insulation is specified, shotcrete is applied to both sides of a polystyrene panel previously covered with metal mesh. The metal mesh fully penetrates the insulation layer, thus creating additional thermal bridges.

Qualification of Construction Workers

Construction work and craftsmanship is not very highly regarded in Iran and is a rather unpopular occupation. Accordingly, many of the workers in this sector are individuals for whom professions deemed more sophisticated and desirable remain out of reach due to their lack of education and training. A large number of them come from poorer countries in the region and work under substandard conditions and for low wages. Many construction workers have insufficient reading and writing, numeracy and calculation skills. This greatly impairs technical communication involving sketches, drawings, descriptions, instruction manuals, etc.

Most of the laborers are unskilled and have little useable experience. They are not sufficiently familiar with the specialist workmanship required for a given task. This is particularly evident whenever problems arise and situations deviate from the “norm”. In many instances, problematic situations and flawed implementation are not even recognized. This in turn can easily lead to consecutive errors and potential causes of damage.

According to statements made by site managers, work processes are broken down into very small steps. Individual workers only execute certain work stages, e.g. only shuttering, only reinforcing, or only concreting. Rarely will the same person execute several different work steps, and thus there is little chance for any understanding of up- or downstream processes and their interconnectedness.

In a five- or six-man work crew, there is usually one member who is somewhat more experienced than the others. He will ‘show the others the ropes’, or give piecemeal instructions for every small step of the task at hand. In terms of professional qualification, this system has proven to be ineffective, as the work steps are essentially carried out ‘mechanically’ without reflection or an understanding of their context. In talks with observers, site managers and experts all agreed that there is a clear need for higher-grade, comprehensive vocational training for construction workers.

Although there are construction sites with a certain percentage of more highly qualified personnel, these workers often fail to apply their knowledge and expertise in a consistent and deliberate manner. This is particularly unfortunate because it puts the long-term effectiveness of training measures into question. The reasons are complex and have not been sufficiently examined. The talks conducted by observers did shed light on at least some reasons behind this lack of consistency. A primary reason is the lack of appreciation for craftsmanship in construction work. Those working in the field easily gain the impression that it does not make a difference whether they carry out their work conscientiously or not. After all, the end result for them is the same: a lack of recognition and low wages. Motivation, effort, and professional ambition remain largely unknown terms within the industry. There is also a widespread lack of awareness of the impact that individual responsibility has on the outcome and quality of the construction project. Building materials, equipment and tools are not appropriately perceived in terms of their monetary value and as a scarce resource which should be preserved and treated with care. Thus, wasteful and ecologically unsound practices are commonplace.

One major problem is grossly inadequate or nonexistent direct communication between the various parties involved in the construction process. This makes it difficult to implement the work stages in the technically correct order, which results in otherwise easily avoidable reworking and partial deconstruction, as well as improvised, non-professional solutions. An example is the post-construction execution of ceiling and support structure breaches which damage or expose the reinforcement. The load-bearing capacity and safety-relevant functions are compromised, provoking damage as a consequence. Consultations are generally held only with subcontractor executives and site managers, whose presence on location is too limited. The situation means that changes in the execution of construction work, or the rectification of deficiencies, require an inordinate amount of time and are often not implemented despite the need being recognized.

At present, the main objective in Iranian residential construction is to erect new buildings as quickly as possible in an attempt to address the acute housing shortage. Unfortunately, the overwhelming demand for housing is accompanied by a lack of raw materials and a severe shortage of qualified personnel for the execution of construction work.

Use of machinery, equipment, and vehicles

Generally, construction vehicles and machines are used for earthworks. Large construction sites have concrete mixing plants installed, shortening distances and transport times. Cranes are available only on large-scale construction sites. On smaller building sites, materials are transported to the upper floors by way of transport rolls. In concreting, internal vibrators are used to compact the concrete, the proper handling of which could not be ascertained.

There was a mixed response in regard to the issue of qualifying certifications for the operation of certain machines and equipment. The number of certificates required is limited, and apparently varies from site to site. There seems to be neither any general, binding regulations in this matter nor any provisions by insurers.

A certificate is generally required for welding work. However, improper handling of welding equipment and neglect of work safety guidelines were observed repeatedly. As the visits to several training facilities near Tehran showed, great importance is attached to professional welding training. Unfortunately, the number of workers with this occupation/competence fluctuates strongly on the construction sites, as there are other industries that offer better pay for qualified welders. Moreover, construction workers are held in very low esteem by the public. Therefore, additional training programs alone will not solve the problem. Supporting measures and higher wages are absolute necessities.

Handling of Reference Documentation

According to several concurring statements, written reference documentation and drawings are used exclusively by site managers and supervising engineers. Only on very large construction sites will subcontractors also receive copies of the constructional drawings and accompanying specifications. Hence the executing workers generally cannot refer to drawings, but must rely solely on verbal instructions from their superiors.

Faulty implementation due to misunderstandings and lack of communication is therefore frequently observed. Yet it will require more than merely making the reference documentation more accessible to remedy this situation. The underlying problem at the work execution level is the lack of necessary skills and competence to understand and utilize the information contained in the documentation.

Work Organization on the Construction Sites

On large and medium-sized construction sites, work is organized according to construction schedules very similar to those found in Germany. In Andisheh, for example, the site manager presented construction schedules, target/performance comparisons, and personnel schedules that corresponded to the construction sequence.

For large-scale construction projects, subcontractors are commissioned by the site manager, who is also responsible for inspecting and approving the work of the subcontractors. There is no ongoing communication between the workers of different work stages or trades.

On small, private construction sites, the builder-owner himself is commonly involved in the execution of construction work. In most cases, he does not possess the knowledge or experience required. This means that in the informal and private sectors, it almost certain that problems concerning construction sequence and quality will arise. Construction supervision is not sufficiently ensured and, in fact, is often not performed at all. An engineer must, at the very least, issue a Construction Certificate for the building as a written record of a very limited set of key data regarding the building. However, the engineer's personal presence on the site is neither legally required nor common practice.

Occupational Health and Safety

There is an abundance of eye-catching, brightly colored warning signs across the larger construction sites, advising caution. For example, there are warnings against falling objects or alerts to wear protective gear.

On well-organized construction sites, adherence to these safety guidelines is monitored by trained personnel. The site managers in Andisheh, for example, stated that there were four safety officers present on the site we visited. Their respective responsibilities cover the assembly of the electrical systems, the construction itself, all installations such as heating and air conditioning units, and the supervision of construction vehicles and machines. This means that the safety officers direct the works carried out in individual subsections and are responsible for maintenance and repairs, as well as timely completion.

Since occupational safety requires additional time and effort, this creates a certain conflict of interests. Therefore many important safety precautions are not taken and there is a lack of protective gear. In most cases, the workers themselves are given this responsibility. In Andisheh at least, they are instructed in work safety once a month, which in the context of the existing practice can only be called exemplary.

Similarly, work and safety scaffolding is rarely used and generally fails to meet applicable standards. Scaffolding is deployed only where it is absolutely necessary, e.g. for facade work. Protective guards are almost never used.

Overall Impression of Construction Sites and Workplaces

The overall impression gained from the visits and inspections ought not to be assessed by German standards, as the general conditions in Iran are very different. The Iranian construction sector is not oriented on the principles of free enterprise in a comparable way. The big building companies implementing the large-scale residential construction projects are either controlled by public agencies, or at the very least, strongly influenced by the authorities. Private building projects, and hence the majority of all building construction, on the other hand, mostly take place in the informal sector and are therefore primarily guided by private interests. In an effort to cut costs, but also due to a lack of experience, the existing building regulations, sustainability and energy efficiency standards, work safety guidelines and other general requirements are often circumvented. This sector is difficult to assess; however, there appears to be a pressing need to make the relevant information readily available to private house builders. Developing methods to achieve this should be the focus of future research and cooperation.

The visits initially created the impression that construction was proceeding in a well-ordered manner and according to plan. However, a closer look revealed many shortcomings. The most prevalent problems are documented in the catalogue of damage and problem cases that follows, and suggestions are presented on how to improve the work processes and results.

The biggest problems in the execution of construction work are largely, albeit not exclusively, caused by the lack of professional qualification and expertise on the part of the construction workers. Key reasons for this misguided development are found in the observable disregard for the work itself, the disrespect and inadequate pay for the people who carry out this work, and the fact that building materials, resources, tools and equipment are hardly valued at all. A major obstacle on the path to becoming a competent, learning company is the exceedingly low percentage of permanent staff combined with a high fluctuation rate among workers, who are often hired on a project-by-project basis. Without implementing the necessary improvements in training, in work organization and in safety at work and without creating an awareness of individual responsibility it will be virtually impossible to establish an acceptable quality standard.

The shortage of certain building materials and resources is particularly evident in the area of concrete shuttering: most of the available forming materials have far exceeded the limit of their service life. Different, incompatible systems are mixed. Mandatory maintenance cannot be performed due to the lack of suitable care substances, with hardly any effort undertaken to obtain them. Quality defects in building materials such as cement, additives, or steel become apparent in the poor overall quality of many buildings.

Qualification-Related Construction Site Categories

In terms of work quality and its dependence on the qualification of construction workers, the construction sites can be classified into three categories:

1. *Small housing units / private construction sites with few residential units; the builder-owner is also the building contractor, e.g. executor*
   Quality varies widely and is always dependent on the expertise and skills of the builder. The majority of the construction defects are found in this sector. Providing these builders with essential information, by establishing house builder information centers or similar institutions, should be a top priority.
2. *Medium-sized and larger construction sites with largely unskilled external personnel*
   On most construction sites, the qualification level of the hired labor is very low. The construction workers receive instructions on location for each individual work step from a slightly more experienced worker. This lack of qualified personnel, along with nonexistent or inadequate supervision, is the cause of a multitude of building defects and problems.
3. *Large-scale construction sites run by bigger, well-organized building companies with their own personnel, some of whom are well- or even highly qualified.*
   Some of the major building companies are capable of implementing a high level of construction quality in at least a number of instances. These enterprises provide in-house training for their personnel and aim to retain their staff, and avoid fluctuation, by offering more attractive working conditions. These companies are always able to draw on a certain pool of qualified staff. Executives of these companies have stated that this gives them a competitive advantage in the top-tier construction market.

Qualification Strategy

The responsible governmental departments and institutions have been involved in a long-standing effort to address the deficiencies. However, their success has been limited. The Ministry of Labor had decided that 100,000 construction sector workers should receive training in the period 2010/2011, and funding–albeit insufficient–was provided to this end. Our research was not able to clearly determine how comprehensive said "training" was intended to be. Based on the discussions and our own observations and experiences, however, we can safely assume that its scope is not that of an exhaustive and well-rounded vocational apprenticeship comparable to the German model, which aims to equip participants with a broad range of professional capabilities. Instead, it is more likely that the political decision was guided by a purely functional, short-term objective.

Ultimately, the intended goals are irrelevant, as the entire venture must be judged a failure. It lacked effective concepts for its implementation, and the number of available specialist instructors and suitable on-the-job training sites was insufficient, as we learned from representatives of the Technical and Vocational Training Organization (TVTO) in Tehran. The TVTO is in charge of regulating technical vocational apprenticeships, including training module certification, and operates numerous training facilities for different trades and industries throughout the country. The construction sector has so far been greatly underrepresented. Even the large Instructors Training Center (ITC) in Karaj has, to date, not offered any training courses for instructors in the building trades.

All those interviewed stated that the collaboration with the Young Cities Project should not only focus on energy-efficient urban fabric and buildings, new technologies, construction processes, and materials. In their view, receiving support for the training of construction site personnel is an essential factor for success.

III
Classification of Damage Cases discovered during Construction Site Visits

Usage of different shuttering systems
Improper shuttering execution
Inadequate concrete quality

Possible Subsequent Damages
- bad compression
- insufficient concrete coverage
- reduced load capacity due to reinforcement corrosion

Reconstruction Options
- chipping off the offsets from column to column (heavy workload)

Proper Execution
- preventing the combination of different shuttering systems
- usage of formula concrete
- proper transport and installation
- proper compression and finishing treatment
- paying attention to the instructions of the shuttering manufacturer and monitoring both the concrete quality and construction steps

Shuttering after reinforcement
Incorrect order of construction steps

Possible Subsequent Damages
- no guarantee as to the geometric precision of the surface (dimensional inaccuracy of the component)
- no guarantee of seamless transition between concrete sections (offsets on the concrete surface)
- corrosion of reinforcement due to insufficient concrete coverage
- reduced load capacity of the building element

Reconstruction Options
- deconstruction

Proper Execution
Construction step order:
- shuttering of the first side
- installation of reinforcement
- shuttering of the second side

Unsatisfactory execution of shuttering work
Incorrect execution of transitions
Improper concrete consistency

Possible Subsequent Damages
- no proper transition between concrete sections
- problems with the placement of wall coverings
- extensive rework

Reconstruction Options
- chipping off or troweling with leveling compound

Proper Execution
- checking the shuttering before casting the concrete
- precise shuttering, paying attention to dimensional accuracy

Poor quality concrete surface due to improper shuttering and/or use of too much bond breaker

Possible Subsequent Damages

- deficient adhesion of following coatings

Reconstruction Options

- blasting, grinding down

Proper Execution

Construction step order:

- proper cleaning of shuttering elements
- spreading out bond breaker according to manufacturer's instructions

Insufficient support structure for concrete shuttering

Possible Subsequent Damages
- movement and deformation of shuttering elements of the component while casting the concrete
- safety problem: collapse of shuttering

Reconstruction Options
- large scale filling or elaborate grinding

Proper Execution
- using the correct column dimensions
- solid anchorage of shuttering
- checking the stability and load capacity of shuttering before casting the concrete

Uneven space between reinforcement and shuttering due to missing spacer
Usage of different, uncompatible shuttering systems
Missing connections between shuttering elements (unprofessional connection with wire)

Possible Subsequent Damages

- insufficient concrete coverage (concrete reinforcement bars are visible at the surface of the concrete)
- loss of load capacity due to reinforcement corrosion
- deformation of components surface caused by reinforcement pressure

Reconstruction Options

Before casting the concrete:

- alignment of shuttering elements and connecting them sustainably
- additional propping up against soil and additional fixing
- installation of spacer

Proper Execution

- see Reconstruction Options
- attention to general rules on reinforcement rules

Imprecise reinforcement path with starter bars in an already concrete encased reinforcement
Improper transmission of the load from the column to the base via the reinforcement

Possible Subsequent Damages
- well-directed load transmission into the base impossible
- break down of the construction

Reconstruction Options
- deconstruction

Proper Execution
- providing proper planning and reinforcement drafts at the construction site
- installation of the reinforcement according to rules of reinforcement:
  - execution according to draft
  - sufficient anchoring lengths
  - securing the position of the reinforcement
  - assuring concrete coverage
  - paying attention to the minimum distance between reinforcements
- inspection of the reinforcement (reinforcement approval) by professionals (i.e. structural safety engineer) before placing the concrete

**Improper installation of the reinforcement, much too tight (maybe missing information about minimum distances in planning documents)
Missing spacer, the concrete can only partially surround the reinforcement**

Possible Subsequent Damages

- reduced composite action between reinforcement and concrete
- reinforcement corrosion

Reconstruction Options

- Deconstruction and reconstruction before casting the concrete
- Rearranging the reinforcement in accordance with the construction plan

Proper Execution

- providing proper planning and reinforcement drafts at the construction site
- installation of the reinforcement according to the rules of reinforcement:
  - execution according to draft
  - sufficient anchoring lengths
  - securing the position of the reinforcement
  - assuring concrete coverage
  - paying attention to the minimum distance between reinforcements
- inspection of the reinforcement (reinforcement approval) by professionals (i.e. structural safety engineer) before placing the concrete

Incorrect bending radius of the reinforcement steel, leading to insufficient bending accuracy
No acceptable device for bending the reinforcement steel

Possible Subsequent Damages

- crack development within the bends
- demolition of reinforcement concrete

Reconstruction Options

- setting up an adequate work environment for bending
- providing bending devices for reinforcement steel at construction sites

Diameter of the bending roller is too small, improper order of hoop Reinforcement (shackle locks are arranged without an offset)

Possible Subsequent Damages

- crack development within the bends in the reinforcing steel structure
- concrete spallings in that area

Reconstruction Options

- replacing the hoops, if bending radius is acceptable (inspection by structural engineer necessary)
- otherwise complete deconstruction necessary

Proper Execution

- installation of the reinforcement according to the rules of reinforcement:
  - considering reinforcement drafts made by the structural engineer
  - securing the position of the reinforcement
  - choosing the correct diameter of bending rollers
  - paying attention to the minimum distance between reinforcements
  - inspection of the reinforcement (reinforcement approval) by professionals (i.e. structural safety engineer) before placing into concrete

Exposed access bars of the supporting reinforcement (very common in Iran, building will be continued as needed)
Steel is left exposed to the elements

Possible Subsequent Damages

- reinforcement corrosion, decomposition of the reinforcement after a long corrosion time
- reduction of load capacity, or even total breakdown of the building

Reconstruction Options

- cutting off the steel and protecting it against corrosion (coatings, filling or something similar)
- producing new anchorages for further constructions if necessary (caution: clarification by structural engineer)

Proper Execution

- balancing of construction planning and construction
- avoiding long breaks during construction
- considering potential scheduled heightening within the draft/static

Tie bars are not surrounded by concrete
No composite action between reinforcement steel and concrete
Incorrect concrete recipe, incorrect granulometric composition of construction aggregates, no concrete compression

Possible Subsequent Damages

- reinforcement corrosion
- reduction of load capacity, or even total breakdown of the building

Reconstruction Options

- deconstruction and subsequent new construction

Proper Execution

- ensuring correct concrete recipe
- foreign supervision
- concrete mixing process according to instructions
- sufficient concrete compression

Exposed reinforcement, no concrete coverage
Inapropriate or incorrect concrete recipe
Poor or missing concrete compression

Possible Subsequent Damages
- failure of the load bearing structure due to corrosion of reinforcements

Reconstruction Options
- deconstruction and new construction
- proper concrete sanitation would be very complex and expensive

Proper Execution
- usage of formula concrete
- supervision of concrete quality
- proper transport and installation of the concrete
- proper compression and post-installation treatment of the concrete

Exposed reinforcements, clearly visable concrete transitions (ceiling—column), incorrect concrete composition, poor compression Poor and imprecise shuttering transitions

Possible Subsequent Damages
- failure of reinforcement construction due to corrosion
- declining load capacity
- elaborate reworking/concrete sanitation necessary

Reconstruction Options
Concrete sanitation:
- extensive condition analysis
- proper corrosion protection with high quality, synchronized sanitation systems

Proper Execution
- accurate shuttering
- in regard to concrete coverage, the reinforcement placement needs to be approved before concreting
- supervision of concrete's production according to proper recipe
- execution of concrete compression according to the legal building code

Clearly visible hollows in the concrete, exposed reinforcement, production of concrete with incorrect recipe, poor compression, poor concrete quality, clearly missing supervision of concrete quality

Possible Subsequent Damages

- reinforcement corrosion
- reduction of load capacity, or even total failure of the building
- elaborate reworking/concrete sanitation necessary

Reconstruction Options

- concrete sanitation:
  - extensive condition analysis
  - proper corrosion protection with high quality, balanced sanitation systems

Proper Execution

- accurate shuttering
- in regard to the concrete coverage, the reinforcement placement needs to be approved before concreting
- supervision of concrete's production according to recipe
- execution of concrete compression according to the building code

Blooms at the concrete surface, impurities in the components (i.e. chlorides and sulfates), possibly too low temperature while concreting

Possible Subsequent Damages

- through impurities (chlorides or sulfates):
  - concrete corrosion
  - pitting corrosion at the concrete steel

Reconstruction Options

- laboratory test
- removing the damaged spots
- reprofiling through proper sanitation materials, i.e applying epoxy (depending on impurities)

Proper Execution

- exclusive usage of washed construction aggregates for concrete production
- special measures for unfavorable weather and temperature conditions:
  - heat treatment
  - cooling (summer)
  - keeping it moist
  - covering up with covers and mats
  - preheating the aggregates (at low temperatures)

Improper shuttering, inadequate compression (lower edge in the picture)
Wrong concrete recipe

Possible Subsequent Damages
- reinforcement corrosion
- reduction of adhesion for subsequent building materials/coatings

Reconstruction Options
- large scale filling

Proper Execution
- verification of mixing ratio of the concrete recipe
- precise execution of concrete compression
- cleaning the shuttering after stripping (upkeep of the shuttering extends its durability)

Improper shuttering connection, incorrect consistency, erroneous mixing ratio
Improper scaffolding work

Possible Subsequent Damages
- aesthetic problems
- problems with installation of cladding
- increased rework necessary

Reconstruction Options
- chipping off protruding concrete parts
- spreading out leveling filler

Proper Execution
- precise work while shuttering
- monitoring the concrete recipe and the concreting

Inadequate concrete compression, consistency of concrete mix too stiff
No concrete coverage, position of lower reinforcement visible (bottom of balcony slab), no or incorrect spacers used

Possible Subsequent Damages
- reinforcement corrosion
- load capacity loss
- failure of components
- use of balcony impossible

Reconstruction Options
- concrete sanitation through repair of defects (bottom side of the ceiling) with leveling filler

Proper Execution
- correct concrete consistency
- correct spacer positions
- precise execution of concrete compression

Test cubes for pressure strength test improperly stored
No proper equipment for a concrete laboratory

Possible Subsequent Damages

- imprecise measuring results

Reconstruction Options

- none

Proper Execution

- storage of test cubes in climate controlled box (if available)
- alternatively: storage at a constant room temperature 20 °C ± 2 °C and humidity 65% ±5% (supervision necessary)

Contraction cracks located in new concrete ceiling
Improper concreting, i.e. removal of shuttering too early, too quick dehydration, wrong concrete additives

Possible Subsequent Damages

- reinforcement corrosion
- reduction of load capacity

Reconstruction Options

- filling of hollows with cement paste in the case of hairline cracks and with cement suspensions in the case of larger static cracks

Proper Execution

- sufficient compression of the concrete
- proper post-installation treatment of the concrete
- preventing too fast dehydration by protecting against wind and sun
- supervision of concrete quality

Poor brickwork in terms of quality, heat insulation and construction physics, irregular brickwork bond, grooves are partly too large (straight- and course joints)
Thermal bridges due to steel frames used as lintels
Partial use of quarry stones for an "optimal utilization" of bricks (saving at the wrong end)

Possible Subsequent Damages

- thermal bridges
- high energy demand, for heating in the winter and air conditioning in the summer
- crack formation in the façade

Reconstruction Options

- Installing external thermal insulation composite system (ETICS) in the façade

Proper Execution

- use of highly heat insulating bricks, i.e. autoclaved aerated concrete (AAC) blocks
- appropriate wall thickness
- accurate processing of the materials
- preventing thermal bridges
- consistent and thorough work monitoring

Weakening of brickwork from supply line conduits
Conduit section of the brickwork missing thermal protection

Possible Subsequent Damages

- crack development in the plaster
- high loss of heat
- noise insulation problems
- poor fire protection

Reconstruction Options

- application of a thermal insulation system
- changing the position of supply lines inside the house and/or into the covering
- closing the brickwork

Proper Execution

- keeping slots or discontinuities in the brickwork as small as possible
- closure of unavoidable, weakened spots with proper material (i. e. high quality insulation material)

Improper joint structure (partly due to very large joint thickness, missing mortar)
No brickwork bond

Possible Subsequent Damages
- crack development in the following layers, i.e. final coat
- high energy losses caused by missing material at those spots
- poor load transfer via the brickwork

Reconstruction Options
- full thermal insulation with external thermal insulation composite system (ETICS)
- filling in the hollows
- verification of load capacity by a structural engineer

Proper Execution
- consistent joint structure and bond in the brickwork
- ensure mortar creates a friction-locked connection between bricks
- leveling out dimensional variations of the bricks

Poor quality brickwork
Alignment of the outer wall edge is not uniform
Random placement of bricks, some brick openings run straight through the wall
Improper connection between brickwork and steel girder
Installation of defective material, i.e. bricks
No brickwork bond

Possible Subsequent Damages

- cracks in the subsequent exterior surface (plaster or coverings)
- high heat loss due to improperly laid bricks

Reconstruction Options

- installation of external thermal insulation composite system (ETICS)

Proper Execution

- proper creation of brickwork bond according to regulations
- laying bricks in the correct direction
- usage of safe construction material

Heat insulation reduced due to connection with the metal netting
Weakening of the insulation and development of thermal bridges caused by piercing metal joints

Possible Subsequent Damages

- high energy loss caused by thermal bridges
- condensation damages

Reconstruction Options

- deconstruction and constructing a proper wall system with heat insulation

Proper Execution

- wall construction and structure according to regulations on building physics and national requirements concerning energy efficiency of buildings (avoid planning errors!)

Too much distance between wall and façade elements

Possible Subsequent Damages

- crack development in the façade
- failure of mounting hardware and falling down of façade panels

Reconstruction Options

- anchorage of the façade panels

Proper Execution

- stable anchorage of façade panels in consultation with a structural engineer
- usage of verified mounting systems
- supervision of execution

Brickwork not flush with outside concrete bar

Possible Subsequent Damages

- elaborate reworking, filling or chipping off (if possible regarding to a statically stable construction)

Reconstruction Options

- filling
- chipping off
- leaving it the way it is if aesthetically and functionally acceptable

Proper Execution

- use of a water level
- paying attention to brickwork alignment from both the inside and outside

Improper execution of wall connections (no connection between wall and ceiling)

Possible Subsequent Damages

- unstable walls and danger of collapse in the case of earthquakes
- enormous energy losses

Reconstruction Options

- close irregularities in the upper part of the wall through fitted AAC blocks (using a saw)

Proper Execution

- see reconstruction options

Steel skeleton visible at the pediment
Steel girders stick out of the pediment and are exposed to the elements (often visible defect in Iran)

Possible Subsequent Damages
- corrosion of the steel girders
- reduced load capacity
- loss of heat energy (thermal bridge)

Reconstruction Options
- cutting off protruding girders
- proper sealing with minimum coverage (coating, plaster)

Proper Execution
- properly integrated planning
- closed and physically safe façade surface
- consideration of corrosion protection
- prevention of thermal bridges caused by the structure

Improper execution of profile attachment to bordering components (i. e. missing sealing tape and sealing adhesive)
Steel structure has no fire protection (missing coverage)

Possible Subsequent Damages
- crack development
- noise insulation problems caused by missing joint sealing
- quick failure of the steel girders in case of fire

Reconstruction Options
- rework: subsequent installation of sealing tape
- fire protection for the steel girders, i. e. casing with dry lining panels or installing a fire resistant layer

Proper Execution
- installation of dry walls according to the instructions of the manufacturer
- supervision and verification by professionals
- proper anchorage of the substructure to the steel structure

Improper connecting arrangement: gypsum cardboard is placed on the raw ceiling
Screw head punctured the gypsum cardboard (screws are screwed in too deep)

Possible Subsequent Damages
- grip of the panel is not secured
- risk of panel fracture
- danger of mold formation (especially in the wall cavity) caused by rising moisture from the concrete

Reconstruction Options
- placing new screws
- setting new panels at a distance from the unfinished floor

Proper Execution
- no puncturing of the gypsum cardboard with screw heads
- fixing gypsum cardboard a sufficient distance from the raw floor on the substructure

Improper connection between doorframe and wall (missing connection profiles)
Irregular steel grid frame
Missing structural fire prevention for the steel girder

Possible Subsequent Damages

- doorframe can be torn out of the wall due to mechanical stress
- increased risk of fire at cable bushings
- less stability of the drywall close to the steel girder bushing
- sound bridges
- difficulties at subsequent reconstructions

Reconstruction Options

- replacement of the profiles at the door frame using UA profiles (door installation profiles)
- fire protection cladding or fire protection coating for the steel grid

Proper Execution

- professional bushing for cables and steel grid
- flexible cable connections
- fire protection cladding or fire protection coating for the steel grid

Improper masonry connection
No masonry bond (bond system)
No masonry connector (flat steel anchor)

Possible Subsequent Damages
- cracks in the subsequent exterior surface (plaster or coverings)
- wall collapse in the case of earth quakes or other mechanical loads

Reconstruction Options
- deconstruction, new construction
- reinforcement filler (just for crack development prevention)

Proper Execution
- usage of masonry connectors/anchors
- masonry bonding according to standards
- full-length horizontal joints

Interior walls exceed the limits of the floors and ceilings
Walls jut out over the outer edge of the uncovered ceiling

Possible Subsequent Damages
- reduced load capacity
- expensive rework necessary to achieve a correct wall connection

Reconstruction Options
- filling the ceiling with filling compound
- chipping off the overhanging masonry

Proper Execution
- brick laying according to masonry standards and to the plans
- paying attention to outer alignment while erecting inner walls

Interior walls exceed the limits of the floors and ceilings
Walls jut out over the outer edge of the uncovered ceiling

Possible Subsequent Damages
- reduced load capacity
- expensive rework necessary to achieve a correct wall connection

Reconstruction Options
- filling the ceiling with filling compound
- chipping off the overhanging masonry

Proper Execution
- Brick laying according to masonry standards and to the plans
- paying attention to outer alignment while erecting inner walls

Clearly visible plaster discoloration in the upper part of the masonry, underneath the attic and windows
Attic is not covered with weatherproofed material
Insufficient covering, missing drip edges, insufficient overhangs
No window sills

Possible Subsequent Damages
- moisture penetration of the masonry
- mold formation in the apartments
- spalling of the plaster
- crack formations

Reconstruction Options
- subsequent proper coverage of the attic using zinc plate
- installation of window sills made from metal, natural stone or plastic with drip edges and a slight slope to the outside

Proper Execution
- sufficient overhang at the upper roof closure
- using window sills
- draining rain water off the building

Improper manufacturing of the floor screed, making the correct mix proportion impossible
Insufficient mixing
Mixing of the floor screed at the job site
Uncertain quality and physical properties

Possible Subsequent Damages

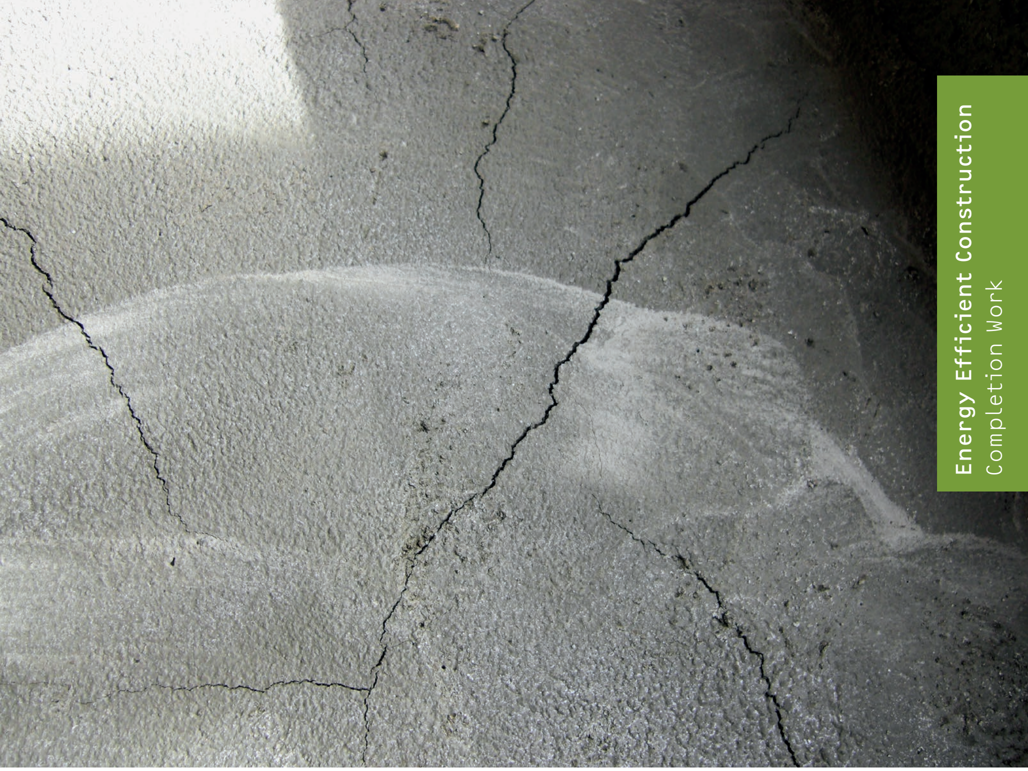
- stability not guaranteed
- crack formation in the floor screed itself and in floor coverings (i.e. tiles)

Reconstruction Options

- removing loose parts
- repairing cracks through surface strengthening with synthetic resin (epoxy resin)

Proper Execution

- using floor screed blenders and floor screed pumps
- using ready mixed mortar
- paying attention to the correct mix proportion
- complete and homogenous mixing in blenders
- system controlled water dosage



Crack formationin floor screeds surface
Incorrect floor screed recipe
Improper manufacturing process (i.e. manual mixing on site)
Possibly missing reinforcement

Possible Subsequent Damages

- crack formation in the floor screed itself and in floor coverings (i.e. tiles)
- time-consuming and costly reconstruction

Reconstruction Options

- removing loose parts
- repairing cracks through surface strengthening with synthetic resin (epoxy resin)

Proper Execution

- supervision of manufacturing, installation, and post-installation treatment of floor screed by construction management
- ensuring constant quality through proper manufacturing processes (using machines, silo) or through the use of prefabricated bagged goods
- reinforcement for prevention of shrinkage cracking
- paying attention to external influences like temperature, wind, and moisture

Improper execution of the arch
Unevenly laid fraction tiles
Uneven joint alignment
Sample from the training workshop (bad example)

Possible Subsequent Damages

- improper execution during training courses leads to poor results at construction sites

Reconstruction Options

- deconstruction and rebuilding

Proper Execution

- exact arch calculation
- calculation of tiles, conical cutting of tiles
- paying attention to proper, clean and high quality work in the training process

Entering recently poured screed layer, even with wheelbarrow
Uneven screed surface

Possible Subsequent Damages

- crack formation in the floor screed itself and in floor coverings (i.e. tiles)
- time-consuming and costly reconstruction
- reduced stability and plainness, less quality
- costly rework

Reconstruction Options

- application of leveling layer (fine filler)
- milling off bumps
- mending in case of crack formation

Proper Execution

- check accessibility of the screed floor before entering
- pay attention to treatment instructions of screeds
- trowel the screed with a screed template
- height control at the one meter level/cutting check

Poor floor breakthrough
Steel frame subsequently welded on to the reinforcement of the ceiling
Exposed, broken reinforcement

Possible Subsequent Damages
- corrosion of reinforcement bars located in the ceiling
- reduction of load capacity, or even total breakdown of the building

Reconstruction Options
- loosening steel frame from the reinforcement of the ceiling and anchoring it properly in the concrete
- produce sufficient concrete coverage
- capacity load check by structural engineer

Proper Execution
- planning of floor breakthroughs in advance
- additional reinforcement around the lift shaft
- proper shuttering of the opening before casting the concrete

Unnecessary ceiling load due to different mineral aggregates and concrete residuals

Possible Subsequent Damages

- load capacity of the ceiling is affected through additional material
- reduced earth quake resistance
- additional costs for temporary storage of construction material

Reconstruction Options

- chipping off and proper disposal of the redundant material

Proper Execution

- clean workspace
- no temporary storage of construction material at finished components
- proper disposal and recycling of construction material leftovers

Deconstruction due to improper workmanship (happens often at Iranian construction sites)
Execution errors caused by deficient planning and/or supervision of work

Possible Subsequent Damages
- wasting construction material
- rising costs
- extended construction time
- low appreciation of workmanship connected with continuously shrinking motivation

Reconstruction Options
- none

Proper Execution
- accurate construction planning
- clearly described construction steps and regular supervision at the construction site
- no acceptance of poor work results
- better qualification/training of construction workers
- higher appreciation of workmanship and material

Unfavorable location of the heater

Possible Subsequent Damages

- inefficient heating
- suboptimal air circulation and room climate
- higher heating costs

Reconstruction Options

- relocation of the heater

Proper Execution

- placing the heater underneath the window

No double glazed entrance doors in windy area

Possible Subsequent Damages
- heat losses cause higher energy expenditure in cold seasons
- quickly raising indoor temperature in summertime—possibly requiring air conditioning

Reconstruction Options
- replacing single glazed window elements with double glazed window elements
- construction of a storm porch if space is available

Proper Execution
- considering double glazing in the planning process
- supervision of construction execution

Considerable gap between window frame and masonry
No usage of joint material

Possible Subsequent Damages
- impacts air supply
- heat losses in wintertime
- increased energy demand

Reconstruction Options
- closing the joint with permanently elastic sealing material that meets thermal insulation requirements

Proper Execution
- filling the gap between window and interior wall with mineral fiber insulation

Unprotected roof drainage system during the construction phase

Possible Subsequent Damages

- choking of drainage canal (inside gutter) with mortar and construction materials
- obstruction of rain water drainage
- water retained on the roof
- uncontrolled moisture penetration of walls and ceilings

Reconstruction Options

- cleaning of drainage pipes manually
- exposing and if necessary replacing drainage pipes
- covering/protecting the drainage system during construction

Proper Execution

- temporary closure of the draining device
- protecting pipe openings against impurities during construction

Improper execution of weld knot: poor welding seams

Possible Subsequent Damages
- cracks in the masonry
- breakdown of the construction

Reconstruction Options
- supervision of correct dimensioning by structural engineer
- grinding the seams
- new and proper welding

Proper Execution
- grinding fillet welds down to the root base
- removing paint and rust from the seam area
- proper welding
- employment of well-trained welders

Improper execution of a bracket weld: poor welding seams, poor connections

Possible Subsequent Damages
- failure of single seam connections
- danger of total collapse

Reconstruction Options
- supervision of correct dimensioning by structural engineer
- grinding the seams
- new and proper welding

Proper Execution
- prefabrication of brackets in a workshop
- ensuring exact cutting
- execution of just the assembly seams at construction site
- employment of well trained welders

Insufficient formation of edge weld

Possible Subsequent Damages
- breakdown of construction

Reconstruction Options
- removing edges completely
- alignment of beams
- producing new edges in a workshop and welding properly to the beams
- providing joining with reinforcements

Proper Execution
- see reconstruction options
- employment of well trained welders

Disastrous execution of beam connection welds

Possible Subsequent Damages
- total breakdown of construction

Reconstruction Options
- dismantling: grinding the welding seams at the connection and separate the longitudinal girder from the column
- redesigning and executing girder connection in consultation with structural engineer

Proper Execution
- preparing proper connection after adjusting it with straps or gusset plates
- proper welding
- employment of well trained welders

Incomplete connection of the beam
Poor welding seams

Possible Subsequent Damages

- failure of the connection, breakdown

Reconstruction Options

- clarification of the situation in terms of beam design, beam dimensions and requirements in consultation with structural engineer
- dismantling, grinding seams and setting proper welding seams

Proper Execution

- creation of a proper connection version in cooperation with a structural engineer and a welding engineer
- proper welding by trained personnel

Improper storage of construction material
Orderless and unsorted material

Possible Subsequent Damages

- construction material becomes useless, e.g. through moisture
- mechanical damage of construction material
- high loss of material
- quality reduction due to usage of damaged material

Reconstruction Options

- storing construction material in an appropriate manner and location

Proper Execution

- storing construction material on a solid base i.e. wooden pallet
- protecting material against moisture and other influences
- not using inappropriate stored and probably damaged material

Improper storage of construction material and construction waste
Construction material and construction waste become partially mixed

Possible Subsequent Damages
- massive losses of material quality
- waste of material

Reconstruction Options
- separation of new construction material (front part) from construction waste (rear part)

Proper Execution
- keeping a clear distance between construction material and construction waste storage
- using only properly stored construction material in order to meet the required quality

Missing or improper scaffolding
No fall protection, handrail, knee rail, or guard board
No continuous safe working deck
Missing ladders
Missing diagonal struts

Possible Subsequent Damages

- danger of accidents and falling
- severe injuries
- collapse of the scaffold
- endangering uninvolved people
- quality defects caused by bad working conditions

Reconstruction Options

- adding the missing facilities

Proper Execution

- paying attention to safety at work during the planning process
- proper scaffold construction and installation
- safety advisor at the construction site

Insufficient scaffolding for welding

Possible Subsequent Damages

- safety of workers is not guaranteed/danger of accidents
- reduced quality work is to be expected

Reconstruction Options

- installation of a scaffolding meeting safety regulations

Proper Execution

- mounting the scaffolding according to safety regulations
- ensuring sufficient safety at work
- ensuring good conditions for high quality work
- briefing and occupational safety trainings for workers

Disregarding occupational safety in shell construction of stairs
Missing stair railings as fall protection
No safe stair treads (only wire straps)

Possible Subsequent Damages

- danger of accidents for workers
- serious injuries possible

Reconstruction Options

- installation of guardrails and stair treads
- using construction elevator (do not use bare brickwork stairs)

Proper Execution

- safety installations according to reconstruction options

Unorderly and improper storage of construction materials
Open fire at the construction site to warm up construction workers

Possible Subsequent Damages

- danger of accidents
- danger of fire
- emergency escape routes blocked
- damaging construction material and subsequent construction defects
- confusion, waste of construction material
- increased time- and work effort

Reconstruction Options

- clearing up the workplace
- extinguishing the fire

Proper Execution

- handling construction material with care (transport, storage etc.)
- arranging a recreation area for breaks
- proper disposal and recycling meeting the requirements of sustainable and energy-efficient construction

Missing barriers, protective structures, or other safety measures for passersby

Possible Subsequent Damages

- accidents caused by tools or construction materials falling down

Reconstruction Options

- installation of protective scaffolds and barriers

Proper Execution

- paying attention to occupational safety during the planning process
- proper construction site arrangement and construction site security
- safety advisor at the construction site

Missing welding equipment, e.g. welding table
Missing personal protection gear (eye protection, hand protection, etc.)

Possible Subsequent Damages

- execution errors caused by poor working conditions
- increased danger of accident and danger of injury
- eye damages after a short period of time

Reconstruction Options

- no execution of work under such conditions
- procure missing equipment
- supplying personal safety equipment (safety glasses, shield, safety shoes, safety gloves, spark protection, etc.)

Proper Execution

- paying attention to safety at work during the planning process
- creating appropriate working conditions for, and compliance of safety rules during, welding work
- safety advisor at the construction site
- briefing and occupational safety trainings for workers

Soil piles and excavated material too close to the existing building and without security

Possible Subsequent Damages

- uncontrolled pressure on the gable wall of the building, with the consequence of:
  - wall deformations
  - crack formations
  - denting whole wall panels
- damage of the uninsulated exterior wall due to moisture from the earth fill

Reconstruction Options

- immediate removal of the soil

Proper Execution

- not storing construction waste, soil, and aggregates close to a building

Too much distance between housing partitions

Possible Subsequent Damages
- insufficient fire protection, heat insulation, and noise insulation

Reconstruction Options
- closing the join with consideration of fire protection, heat- and noise insulation
- finding solutions in cooperation with any involved parties in the construction project

Proper Execution
- paying attention to proper execution of separation and expansion joint during the planning process
- execution of separation and expansion joints according to the planning
- the site manager ought to notice possible planning mistakes and to correct them according to prior agreement

Missing mounting elements for the air conditioning canals
Mounting the canals on the wall leads to missing connection between ceiling and wall

Possible Subsequent Damages
- deformation or collapse of the canals
- insufficient noise insulation

Reconstruction Options
- using approved mounting elements
- anchoring the canals at the concrete intermediate floor

Proper Execution
- see reconstruction options
- professional planning and optimizing of cables to minimize costs and improve housing quality (noise reduction)
- supervision of work execution

Improper laying of electrical cables
Unsecured electric cable connection

Possible Subsequent Damages
- risk of electric shock for workers

Reconstruction Options
- fixing cable ends to avoid extraction
- using cable clips or electrical tape to protect the cable ends

Proper Execution
- installing cables in cable protection pipes or channels
- secure the cable ends with cable clips or electrical tape

Improper pipe installation—unnecessary bends and bypasses
Perhaps missing installation plan

Possible Subsequent Damages
- pipes are easily clogged
- angry residents
- high maintenance and repair costs

Reconstruction Options
- dismantling and new pipe installation

Proper Execution
- professional planning and optimizing of pipe lines to minimize maintenance and operating costs
- supervision of work execution

Breaking through the ceiling to lay pipes
Unacceptable severing of the ceiling reinforcement
Perhaps missing detailed installation planning

Possible Subsequent Damages
- reinforcement corrosion
- reduced load capacity
- failure of the bearing structure

Reconstruction Options
- moving the load from the severed reinforcement in consultation with a structural engineer
- sufficient concrete coverage of the exposed reinforcement

Proper Execution
- consider necessary breakthroughs and pipe routes during the planning process
- mounting reinforcing bars around the openings
- proper shuttering of the opening before casting the concrete
- no welding of reinforcing bars to avoid weakening the reinforcement's cross section

Breaking through finished ceiling to install air conditioning channels Welding the supporting frame to the reinforcement of the concrete structure (strictly forbidden!)

Possible Subsequent Damages
- reduction of cross sections and discontinuance of reinforcement
- risk of corrosion
- reduction of load capacity, or even total breakdown

Reconstruction Options
- moving the load from the severed reinforcement in consultation with a structural engineer
- sufficient concrete coverage of the exposed reinforcement
- anchoring access channels in the concrete

Proper Execution
- considering breakthroughs and pipe ways during the planning process
- mounting reinforcing bars around the openings
- proper shuttering of the opening before casting the concrete
- no welding of reinforcement bars or mats to avoid weakening the reinforcement's cross section

Chiseling channel slots into the new wall in order to install power supply lines/empty conduits
Improper execution of AAC masonry

Possible Subsequent Damages
- weakening of the wall
- reduced load capacity
- poor thermal and noise insulation

Reconstruction Options
- insulating the outside façade, energy-saving reconstruction

Proper Execution
- keeping the slot cross section as small as possible
- cladding the wall with heat insulating mortar after laying the pipe (do not use plaster)

Incomplete insulation of heating pipes

Possible Subsequent Damages
- heat/energy losses

Reconstruction Options
- insulating the open spots

Proper Execution
- including crossing points and arches in insulation efforts

Large opening in concrete wall created post-construction

Possible Subsequent Damages

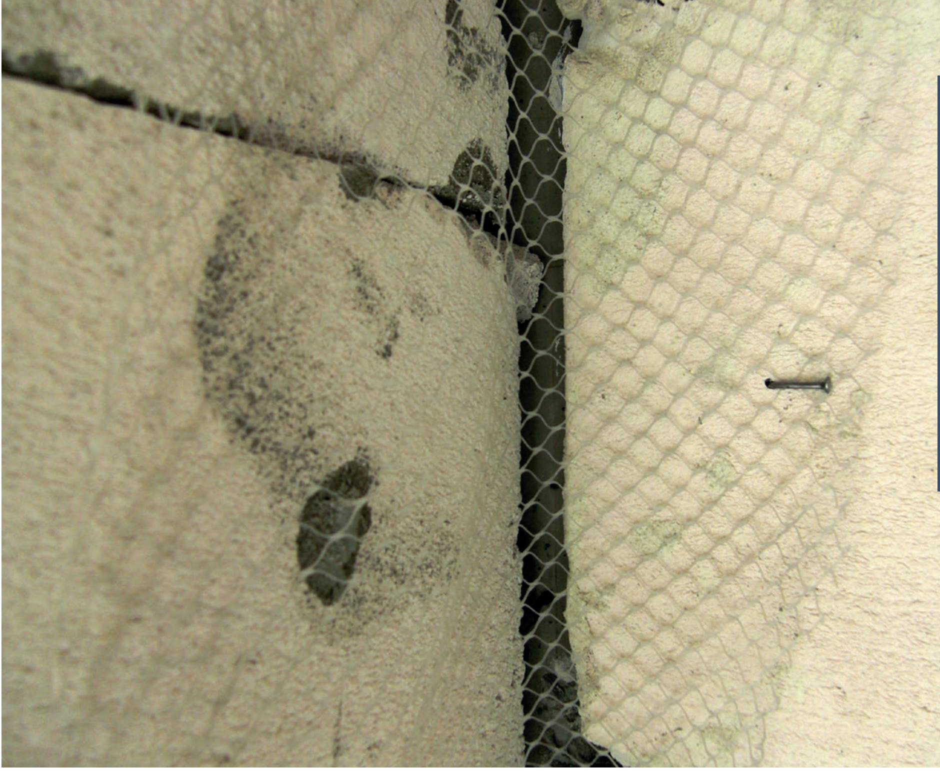
- corrosion of load-bearing reinforcement
- reduced load capacity of the concrete elements, or even complete breakdown

Reconstruction Options

- verification of load capacity by a structural engineer
- ensuring the minimum load capacity of the component through strengthening or anchoring
- protecting the reinforcement against corrosion
- replacing the pipe installation, if nothing else is possible

Proper Execution

- paying attention to installation and assembly openings during planning process
- subsequent production of openings in consultation with a structural engineer



Connection of masonry to concrete column
Installed reinforcement fabric for bridging the cracks located in the plaster because the masonry and reinforced concrete have different thermal expansion coefficients
Reinforcement fabric mechanically (nailed) attached to masonry

Possible Subsequent Damages

- high heat losses as a result of thermal bridges
- crack formation—crack bridging is only possible with properly inserted reinforcement fabric in the reinforcement mortar (reinforcement filler/plaster)

Reconstruction Options

- installation of external thermal insulation composite system (ETICS) in order to avoid energy losses caused by thermal bridges

Proper Execution

- accurate planning, avoiding thermal bridges
- providing the outside of the concrete column with insulation if no ETICS is planned
- proper reinforcing at points of material transition
- embedding reinforcement fabric into the reinforcement mortar close to the surface, wrinkle free and complete

IV
Earthquake Studies

Nadia Poor Rahim | Masoud Rezaei Badafshani | Bernd Mahrin (Eds.)

Introduction

The Country of Iran is located in one of the most earthquake-prone areas of the world. More than 95 percent of the territory is a high-risk seismic area. More than 950 of the around 1,000 Iranian cities belong to affected zones. The two most recent earthquakes left more than 80,000 people dead and destroyed the cities within range.

Beyond geological reasons, planning errors, structural inefficiencies, and inadequate construction work are strong factors in such unbelievably high victim counts and built infrastructure damages. Other countries and regions with similar earthquake-risks have much lower death tolls and destruction levels, showing that effective prevention is possible. Professional planning, well-adapted construction, and, especially in Iran's case, proper workmanship and its supervision are of utmost importance in reducing earthquake damages.

Unfortunately, Iranian construction employs mostly unskilled workers with little experience whose finished work is full of inadequacies and shortcomings which they then attempt to cover up.

The following abstracts and the contribution *Building Pathology* summarize research results from Iranian scientists. They convincingly confirm the vital role of construction workers and supervisors can play in avoiding deficiencies in building construction, highlighting the urgent need for action.

Building damage analysis, a survey of supervision and execution processes which cause earthquake damages in residential buildings in Zarand-Kerman, 2005

This Abstract was translated and edited by Nadia Poor Rahim, Masoud Rezaei Badafshani and Bernd Mahrin on the basis of Saqafî (2006)

On Tuesday, 23rd February 2004, at 5:55 local time (2:25 UT), a destructive earthquake of surface wave magnitude Ms 6.5 struck the Zarand region in the Kerman province of Iran (exactly 14 months after destructive earthquake of Bam on December 2002). According to official figures, about 600 lives were lost and several thousand were injured. Similar to most earthquakes occurring in Iran, this quake struck a relatively barren area. However, there are hundreds of reinforced concrete and semi-engineered (confined masonry) buildings in the region whose behavior, particularly at the epicenter area, is worth examing. In general, the reaction of these structures to the quake, offers some important lessons. The Zarand and Bam earthquakes share the same magnitude and extensive damages. However, the behavior of buildings during the Zarand earthquake is completely different from that seen in the Bam earthquake. Details of the damage shed light on how economic, social and cultural aspects of Iranian society influenced the quality of building construction. A review of earthquakes in Iran (the Manjil-Roudbar earthquake of 1990, Ghaenat earthquake of 1997, and Bam earthquake of 2002) reveals that, of the different stages of design and construction (execution), supervision during the execution stage is the most important factor in the quality of construction and behavior of the building during an earthquake. This research studies the relationship between the earthquake damage a building experiences, and the quality of its construction. This investigation demonstrates the role of building regulations, national codes, supervision, and the quality of materials, in the earthquake resistance capacity of buildings. Lack of supervision and traditional methods in the construction of buildings are identified as the main reasons behind the extensive earthquake destruction in the region.

Previous papers published by the author (based on extended field study) after Ghaenat earthquake and Bam earthquake illustrate the role of supervision on the quality of construction and, as a result, the behavior of buildings during earthquakes. There is a major difference between this research and previous studies on the damages caused by the above mention earthquakes. It relates to the style and the method of construction in the region. Lack of appropriate materials and skilled workers are the main reasons for the damage and destruction of buildings in the rural area. However, local materials and traditional construction methods (and sometimes shortage of financial resources) have resulted in ill-structured design and construction in the area. This research explains the reasons behind the building damage based on field investigation and review of a large number of case studies in the villages destroyed by the Zarand earthquake. This research studies construction of different types of buildings from early stage up to the completion of the building and investigates the role of building codes such as the Iranian Building Regulation No. 2800 for Design of Earthquake Resistant Buildings. The case studies indicate that technical supervision can effectively reduce building damage. This research defines the reasons behind the earthquake vulnerability of buildings in the Zarand region and presents modified methods for preventing extensive damage in future earthquakes.

Survey of damages resulting from execution deficiencies in buildings damaged by the Ghaenat earthquake, May 1997

This Abstract was translated and edited by Nadia Poor Rahim, Masoud Rezaei Badafshani and Bernd Mahrin on the basis of Saqafi (1999) and Gholabchi (2000)

Earthquakes have often caused destruction in our cities and villages, with heavy losses of life and extensive damage to the built environment. Searching for suitable ways to prevent earthquake damage has always been on the state construction agenda, and many studies have been carried out on this matter. Given the fact that Iran is an earthquake prone country, where earthquakes create a great deal of damage, this paper presents an investigation carried out after the Ghaenat earthquake in Khorasan province on 9th May 1997, supported by direct experience in the earthquake-damaged area. The earthquake killed more than 1,700 people, destroyed many villages, and ruined several more. The region was struck by another quake in 1978, after which major restoration of the region's buildings was conducted, and preventive measures were put in place. Yet, in the most recent earthquake, the majority of buildings were again severely damaged, leading to questions about the effectiveness of the previous restoration. This paper presents a comparison of damages in different types of buildings from the Ghaenat earthquake. Important structural aspects and deficiencies in planning, design, and calculation are surveyed. The paper discusses a number of ruined buildings in the area, pointing out damage-causing factors and offers some constructive suggestion about them.

Building Pathology

This contribution is related to the earthquake damages in Bam, 2003, resulting from defective construction and supervision processes. It was translated and edited by Nadia Poor Rahim, Masoud Rezaei Badafshani and Bernd Mahrin on the basis of Saqafî (2004)

The earthquake that struck the Bam Region in the Kerman Province on the 25th of December 2003, left more than 25,000 people dead and ruined the City of Bam as well as the surrounding villages. What is important to note in this national catastrophe, is that not only the traditionally constructed buildings, but also the newly built steel and concrete buildings were seriously damaged. Deficiencies in the planning, design, engineering calculations, execution, and supervision phases of the building construction significantly contributed to this disaster. However, compared to the other phases, it is the construction and its supervision which is of utmost importance due to the fact that people with no expertise are involved in these phases, leading to inadequacies and shortcomings which are then covered up. Although there are geological, planning, and structural reasons behind the damage, the role of building deficiencies created by constructors and supervisors cannot be neglected. In this research, special attention has been given to structural elements and joints as pertains to the specifications of the Iranian Building Code for designing earthquake resistant structures. Pictures from buildings in Bam serve as evidences of inappropriate construction practices.

Walls

Existing wall types in the quake-stricken area were outdoor walls and walls within steel and concrete frame structures (framed as well as load-bearing walls). All wall-types mentioned had severe damage and were, in most cases, destroyed and replaced.

Outdoor Walls

Outdoor walls did not comply with building codes and regulations regarding thickness to height ratios, and they were built with neither bracing, to bear side forces, nor reinforcement (Code 2800).

Outdoor walls which had fallen from the base indicated a lack of underground foundation. Others which had fallen off their stone plinths demonstrated a lack of proper attachment between the wall and the plinth underneath.

Other destruction patterns were also evident, such as lengthy outdoor walls that had entirely collapsed due to a lack of seams (Code 2800). Another deficiency was poor brick-laying, which had weakened the walls and made them more vulnerable to earthquakes. Finally, bricks and the cement mortar had come apart as walls collapsed, evidence of improper mortar-laying techniques, not having soaked the bricks before laying, and use of low-quality materials in the mortar mix.

Framed Walls

The many instances of damage in framed walls were a result of imbalance between wall and frame reactions to seismic forces.

Since the walls had no attachment to framing and/or bracing elements, they were diagonally cracked or had completely collapsed depending on the strength and direction of forces imposed on them.

It is worth noting that walls of multi-story, steel-framed buildings had either easily come off their frames, or had performed as shear walls and caused detachment between columns and beams when subjected to strong force. Noting the existence of steel bracing within the walls of latter case, we can conclude that they must have been either constructed outside the frame, or built within it in a way which didn't obstruct its flexibility. Also, in cases where they were meant as shear walls, their attachment to the frame had to contribute to its strength and they had to be designed symmetrically in the plan to avoid sudden vertical rigidity changes (BHRC 1991, p. 114).

In Bam's multi-story buildings, framed walls had avoided deformation in higher stories yet enhanced it in lower ones where the structure was more flexible, leading to the building's demolition (BHRC 1991, p. 242).

Façade Walls

Detachment from load-bearing walls caused the majority of brick façades to be destroyed. Different levels of harm were evident, from partial damage to complete demolition of the brick façade.

The number of buildings with stone slab façades was also considerable in the inspected area, almost all had been damaged to some degree, according to the type and dimension of stone slabs as well as the movement of the walls supporting them. Although the relatively small number of detached slabs is evidence to the convenience of their installation method, wires manipulated in the installation were very thin, causing them to stretch or tear during the building's movement.

Steel Frames in Building Walls

Imbalance between steel and masonry reactions to seismic forces has caused many instances of soule wall damage (BHRC 1991, p. 261).

Load-Bearing Walls

Inattention to masonry building codes and improper brick and mortar laying made load-bearing walls vulnerable to the earthquake.

Mortar come off of bricks without leaving a trace on them, showing the mortar's weakness and, also, that bricks had not been soaked prior to laying. Another important stability factor is the appropriate proportion of openings to the entire wall surface.

Local inspections and comparison of destroyed walls and the amount of damage each suffered led to the conclusion that cement plastering and stone plate façades greatly reinforced masonry walls.

Ceilings

Boveda Ceilings

These ceilings underwent different degrees of damage, from a few cracks to the demolition of the entire ceiling. A major cause of the damages, apparently, was incorrect construction combined with inattention to building codes and primary regulations.

There were many buildings with boveda ceilings and no compliance with Seismic Building Codes in Bam; buildings with no cross bracing in

the ceiling, no convenient support for beams and end spans and no tie beams underneath the ceiling. Thus, the damage seen in these ceilings was actually entirely predictable.

Boveda arches with no or weak footing and no bracing in end spans did not bear horizontal forces and collapsed in the quake.

A lack of tie beams to support bevoda ceiling beams, no bearing of the beams at the supports, and the concentration of tension on the ceiling-wall junction, in some cases, caused uneven movement of ceiling compartments and consequently the demolition of the ceiling. It is also worth noting that cross bracing was missing from all boveda ceilings (Code 2088).

Tie Beams

Except those few buildings with suitable tie beams—which stood up against seismic shakes—other load-bearing walls were not equipped with suitable tie beams and underwent large-scale destruction. A good example of such buildings are Rajâ'î and Jânbâzân new towns which were 100% demolished due to noncompliance with Seismic Building Codes. Horizontal seismic forces easily displaced and destroyed walls with no tie beams. Even in cases where tie beams did exist, there was still damage, due to deficiencies in the following areas:

a) Concrete Quality

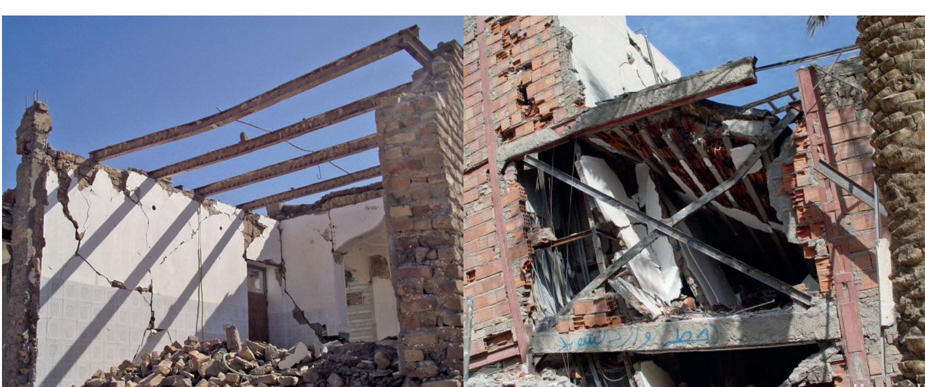
b) Bracing

- Section and number of steel bars
- Large distance between stirrups
- Lack of overlapping in tie beam steel bars

c) Stability

Building Skeletons

Besides composite structures—steel frames and load-bearing walls, none of which were able to demonstrate appropriate resistance to seismic forces and were completely demolished—steel and concrete structures were used in many recently-built buildings. Buildings with concrete structure were more resistant to the shakes than those with steel structures.



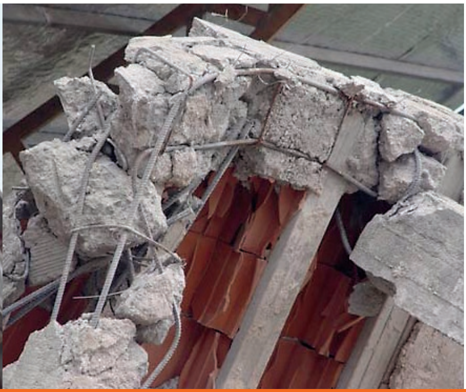
In the Bam earthquake, most steel-framed buildings were seriously damaged. A field study of the wreckage demonstrates the frequency of certain damages:

- Displacement of upper stories due to the bending and twisting of the ground floor (soft floor) columns
- Malfunction of cross bracings within the frames due to the breakage of welds
- Breakage of welds between two columns
- Improper junction between columns and base plates
- Columns' lack of resistance to shear forces beneath the ceiling
- Breakage of welds between columns and beams
- Lack of junction between joists with beams and beams with columns

Although it is necessary to analyze all construction phases, particularly architectural planning and calculations, in order to pinpoint the reason behind the displacement of upper stories from the ground floor—soft floor—the analysis should start with the construction and supervision phase. Breakage of the weld in a single cross bracing increased the tension on beam-column junction and deformed the beam at its junction to the ceiling. Improper welding not only defeated the effectiveness of the cross bracings, but also made the beam-column and beam-joist junctions vulnerable to seismic forces due to the unbalanced distribution of loads between them.

Similar damage was seen in buildings with ceiling joists, due to breakage of welds, misplacement of diagonal steel bars responsible for transferring shear forces and a lack of bracing in joist-steel frame junctions.

In which construction phase was this deficiency created; basic design principles, architectural approaches, technical calculations or construction and maintenance? It is clear that buildings come into existence by going through the entire procedure mentioned. The issue can rise from timing troubles, spatial and economical problems, and labor shortages, all of which affect the quality of construction. Damages resulting from inappropriate construction—along with those rooted in planning and design phases—were evident in all structural elements in Bam buildings. In the construction phase, the problem of skilled workers was easily solvable



(workers were available in Kerman, less than two hours drive from Bam) and high-quality building materials could easily be provided (locally produced). Thus, the source of the problem can be traced to an inattention to building codes and standards. A source which highlights the essential role of construction supervision and control, and the need to more strictly enforce such monitoring.

In light of this, the author suggests that buildings in Iran undergo mandatory insurance for any harm resulting from construction and supervision deficiencies. This way, insurance companies will protect their financial interests by strictly supervising building construction, which will decrease governmental encumbrances and improve construction quality.

V

The Connection between Poor Construction and Energy Consumption Behavior at the Household Level

The Connection between Poor Construction and Energy Consumption Behavior at the Household Level

Sabine Schröder | Jenny Schmithals | Nadia Poor Rahim

The following article is based on the results of a qualitative survey with citizens of the New Town Hashtgerd regarding their energy consumption behavior in the household and for transportation as well as their attitudes towards climate change. The survey was prepared in the framework of the sub-project "Awareness Raising", led by the nexus Institute for Cooperation Management and Interdisciplinary Research within the research project "Young Cities". The aims of the sub-project "Awareness Raising" are to survey the attitudes of citizens in regard to environmental issues, climate change, and energy consumption patterns, in order to develop awareness-raising measures for environmental and climate change issues and to sensitize the population of the New Town Hashtgerd to climate change, sustainable energy consumption, and energy-efficient building.

The survey showed that citizens are very well aware of the poor construction quality of their houses. It also showed that poor construction strongly and negatively influences energy consumption within the household.

In the survey, residents of Hashtgerd New Town were asked for their assessment of the condition of their apartment or building, or, rather, about specific aspects that they approved or disapproved of. One third of the respondents stated that they were content with the construction of their apartment or building, while two thirds of the respondents named one or several problems regarding the construction of their apartment/building.

The most-named problems in regard to the condition of housing units were sewage pipes that were too thin and therefore often blocked and poorly-insulated and leaking water pipes. Valves/fittings are often dripping and often need to be repaired. This leads to high costs for tenants and land-lords, as well as to problems with dampness (e.g. damp spots directly in the flat, damp or wet areas in basements). Responses to questions regarding dampness demonstrate that dampness is a problem for half of those interviewed. This problem was most obvious in building phase three, which was built after phases one and two and is inhabited by people from lower social classes.

Furthermore, leaky windows and doors, and thin or poorly-insulated windows or even holes between windows and walls were highlighted as problems. Some of those interviewed responded that cracks in the walls are visible.

„Although the buildings are newly constructed in Hashtgerd, nothing is done properly and as a result the flats are of low quality standards."
Female, 18, high school student, building phase I

In the winter, the flats are cold or drafty and must therefore be excessively heated. For this reason, nearly all respondents said that, in the winter, they seal up the windows, balconies and, if they have air conditioning, the access channels of the air conditioning with foil, tape, cloth or other materials in order to avoid loss of heat.

„What for? What good does it do if I tape down all the windows, stuff the gap between floor and door with a rug and turn down the radiators, if the entire flat is losing energy because of poor construction quality—like through external walls without insulation? This is as disappointing as trying with a small bowl to remove the water from a boat with a hole."
Female, 28, volunteer, building phase II

These statements show that leaky windows and poorly-sealed air-conditioning systems constitute a problem for many respondents, especially in cold winters. The climate in Hashtgerd is continental (i.e. cold winters and very hot summers). More than half of those interviewed consider their flat to be too cold in the winter. The flats are, however, comfortable in the summer. Few considered their flats to be too hot in the summer.

Ten percent of the respondents poorly valued the general building materials and workmanship of their homes.

Other responses regarding problems concerning the condition of the apartment or house mentioned power lines, missing electric meters, missing gas pipes, missing exhaust hoods, stove fumes that re-enter the flat through power outlets, poorly-laid tiles, shared water meters (viewed negatively), low water pressure, lack of earthquake safety and a poorly-designed floor plan.

Against this background, although awareness of energy saving is definitely there, it is less a matter of environmentally friendly or ideological behavior, but more of taking necessary measures to achieve a certain level of comfort as well as of saving money by heating as little as possible. Almost a quarter of the interviewees said that, in winter, they only heat the rooms that are being used, and they turn down the heating at night or when not using the rooms.

The citizens seem to be sensitized to the topic of heating, possibly encouraged by the extent to which oil and gas prices have risen in past years—and continue to rise—as well as by the occasional scarcity of resources in winter.

The results show that the efforts of the citizens of Hashtgerd New Town to save energy—be they for financial, comfort, or environmental reasons—are impeded by poor construction conditions. Therefore, there is a big opportunity to save energy simply by avoiding holes and leakages during construction, and insulating the buildings, and even more of an opportunity in creating energy-efficient buildings.

Regarding energy-efficient buildings, almost 90% of respondents had heard of energy-efficient building practices. Most respondents associated double-glazed insulated windows and insulated exterior walls with the term energy-efficient building. Technology-oriented solutions for energy-efficient building are not mentioned and may not be well known. Half of the respondents had heard about energy-efficient building on TV, often through advertising, or they had received information about Code 19 (a law on energy-efficient building) through television, which proved to be the most important source of information for citizens regarding environmental issues.

One-third of respondents agreed that there are good conditions for energy-efficient building and that it would be quite feasible, especially in Hashtgerd New Town as there are many construction activities at the moment.

> *"It [energy-efficient construction] need not be complicated. All the prerequisites are there. They are building a lot and you only have to take the opportunity and build an energy-efficient house."*
> Male, 35, cabinetmaker, building phase I

> *"They are showing it on TV, it is easy to be realized."*
> Male, 31, captain at the naval forces, building phase II

> *„The city is young and there is a lot of construction going on. That's the best opportunity for the government. It can pass new laws on energy-efficient building."*
> Male, 35, food buyer, building phase I

However, another third thought that energy-efficient building would only be feasible under certain conditions, e.g. if new laws for the implementation of energy-efficient building are passed or existing laws are enforced. This would also mean that contractors and construction workers should be trained accordingly and be subjected to stricter controls.

> *"As long as construction companies and private investors are only interested in turning profit and the supervising function is neglected, energy-saving construction is not realistic."*
> Female, 62, shop assistant, building phase II

> *"As long as the construction of buildings is performed by unskilled workers, energy-efficient building is not an option."*
> Male, 51, pensioner, building phase I

A final third of the respondents was not able to assess the conditions for energy-efficient building in Hashtgerd, had no opinion on this topic, or had no interest in it. A few respondents argued that energy-efficient building was too expensive.

> *"Energy-efficient building will be expensive and the people cannot afford it. Therefore, they are not interested. If the government were to pass a law and supervise the construction firms, energy-efficient building could perhaps be realized."*
> Female, 22, bachelor, building phase II

> *"Energy-efficient building sounds expensive. The people are here, because they cannot afford to live somewhere else. Therefore it is not imaginable for Hashtgerd."*
> Female, 62, shop assistant, building phase II

These results show that the citizens need more information in regard to the different options of low cost, as well as high-tech, energy-efficient building. More information could also communicate that energy-efficient building does not have to be expensive. The daily experience of Hashtgerd New Town citizens, with resource shortages, rising energy prices, and leaky cladding (i.e. energy-inefficient building), presents a good background against which the advantages of energy-efficient building could easily be promoted.

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Abbreviations

AAC	Autoclaved aerated concrete
BFW-BB	Vocational Advancement Service of the Berlin-Brandenburg Construction Industry Association
BHRC	Road, Housing & Urban Development Research Center (former Building and Housing Research Center), Tehran (Iran)
ETICS	External thermal insulation composite system
IBBA	Institute of Vocational Education (School I Humanities of the Technische Universität Berlin)
LIFE Center	Learning—Information—Forum—Exposition/ Multifunctional Vocational Training Center
TU Berlin	Technische Universität Berlin (Berlin Institute of Technology)
VET	Vocational Education and Training

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VII

Appendix

Interview Guideline

Karen Schmidt | Bernd Mahrin | Nadia Poor Rahim

The interview guideline was developed for construction site visits and expert talks. It was useful for systematically gathering facts and background information about construction practice. Thus it was possible to assess statements relating to the respective frameworks.
A bilingual version (English and Farsi) is ready for download at http://www.youngcities.org/137.html. It may be adapted and used for free. Indication of source is requested.

General Information

Site No.					
Date					
Place, Address					
Construction Company/ Investor					
Construction Project (description, e.g. building's type/use, single building, complex, infrastructure, etc.)					
Responsible Site Nanager					
Building's Function (residential/public/commercial building etc.)	**Size** from ... to ... in m^2				
	Number				
	Total Living Space in m^2				

Further Rooms (number, short description)	Prayer Rooms	Common Rooms	Utility Rooms	Cellar Rooms	Other
Number of Floors					
Situation (notes according to photos)					

Site Personnel		Number	Formation, Qualifications, Experiences, etc.
	Senior Site Manager		
	Site Manager		
	Foremen		
	Assistant Foremen		
	Semiskilled Workers		
	Unskilled Workers		

Workmanship

What types of work are conducted at the site?

Are the workers specialized to particular fields of work?

How do the workers of different fields communicate?

What quality defects are seen as a result of the working processes?

What quality defects are seen during the working processes?

Preferred Executions, Techniques, and Materials

Basements/Foundations	**Strip Foundation**	**Bottom Slab** (spread foundation)	**Special Foundation** (e.g. piled foundation)	**Others**	**Remarks**	
Support Structure	**Steel Skeleton Building**	**Reinforced Concrete Construction**	**Brick Lining Material**	**Others**	**Remarks**	
Ceiling	**Monolithic Reinforced Concrete**	**Concreted Filigree Elements**	**Prefabricated Elements**	**Others**	**Remarks**	
Wall Construction	**Brick Masonry**	**AAC**	**Reinforced Concrete**	**Other Material**	**Wall Structure**	
					single-leaf	**double-walled**
	Special Characteristics (Lintel Types, Special Bricks, Installation Bushings)					
Wall Thickness	**Outside Walls**	**Interior Walls**	**Load-Bearing Walls**	**Non-Load-Bearing Walls**	**Remarks**	
Wall Coating	**Plaster**	**Tiles/Panels**	**Wallpaper**	**Wooden Sheathing**	**Others**	**Remarks**

Roofs	**Flat Roof**	**Sloped Roof**	**Other Constructions** (list)		**Remarks**	
Roof Structure	**Wooden Construction**	**Steel Construction**	**Reinforced Concrete Construction**	**Other Constructions** (list)	**Remarks**	
Roof Covering	**Roof Tiles**	**Metal**	**Roofing Fabric**	**Proofing Paint Coat** (e.g. Bitumen)	**Protecting Isolations**	**Other Constructions** (list)
Roof Drainage	**Gutters**	**Downpipes**	**Roof Runoff**	**Other Constructions** (list)	**Remarks**	
Doors/Windows		**Wooden Frames**	**Plastic Frames**	**Metal Frames** (e.g. Aluminium)	**Special Characteristics** (e.g. wall sockets by special profiles and caulking strips)	
	Single Glazing					
	Double Glazing					
Window Sills, Sill Blocks	**Plastic**	**Virgin Stone**	**Metal**	**Drainage Area**	**Overhang**	**Other Constructions** (list)

Floors

	Tiles or Panels	Plastic	Coating on Concrete or Pavement	Carpeted Floor	Laminate/ Parquet	Other Constructions (list)
Living Rooms, Bedrooms						
Bathrooms and Toilets						
Corridors etc.						
Common Rooms						
Cellars, Utility Rooms						
Exits, Passages						
Shoulder Construction						
Footfall Sound Insulation						

Insulating Material	**Area/Material**	**Mineral Rock Wool**	**Polystyrol**	**Animal Material (Sheep's Wool)**	**Vegetable Material**	**Others** (list)
	Walls/Façades					
	Floors					
	Foundation					
	Cellars					
Façades	**Plastered Masonry**	**Panneled Masonry**	**Insulated Masonry**	**Other Constructions** (list)	**Remarks**	
Basement	**Height**	**Type of Insulation**	**Material**	**Protective Coating**	**Other Constructions** (list), **Remarks**	
Heating—Energy Source	**Oil**	**Gas**	**Wood**	**Electricity**	**Other Constructions** (list), **Remarks**	

Heat Generator	**Conventional Heating Boilers**	**Condensing Boilers**	**Oven/Fireplace**	**Combined Power Unit**	**Other Constructions** (list), **Remark**
Use of Renewable Energies	**Solar Thermal System**	**Water-Water Heat-Pump**	**Air-Water-Heat-Pump**	**Photovoltaic System**	**Other Constructions** (list), **Remark**
Heating—Heat Distribution	**Radiator**	**Floor Heating**	**Wall Surface Heating**	**Ceiling Heating**	**Other Constructions** (list), **Remark**
Heating General Facts	**Central or Peripheral System?**				
	Positions of Radiators?				
	Adjustable Radiators?				

Radiators can be preset (Thermal Compensation)?

Circulation (Fall System, Pumps, Adjusted High-Efficiency Pumps)?

Water Supply and Waste Water Management (General Rating)

Electrical Systems (General Rating)

Use of Machines and Equipment	
Which machines and equipment are in use?	
Who uses these machines and equipment?	
For which working processes are these machines and equipment usually used?	
How are these machines and equipment usually used?	
Are these machines and equipment used appropriately?	
How are these machines and equipment maintained?	
Are there formal qualifications or examinations required for using special machines and equipment (e.g. crane driving license or welding certification)? Which ones?	
Which measuring and testing instruments are used?	
Who uses these measuring and testing instruments?	

Dealing with Construction Documents

Who uses which kind of construction documents at the site?		Site Manager	Foremen	(Experienced) Workers
	Construction Drawings			
	Tender Documents			
	Building Description			
	Calculation Documents			
	Static Plans			
	Subsoil Expertise			
	Building Permit			
Are the workers able to read construction drawings?				
Is there documentation, such as construction diaries?				

Work Organization at the Construction Site

How are the work processes organized at the construction site?

Are there detailed construction schedules?

Are there comparisons of target and actual construction times?

Are there comparisons of the target and actual materials used?

How are the wages calculated (e.g. depending on working time, on the quantity of material used, …)

Security and Safety at Work, Fire Protection, Health Care

Is there a safety coordinator or a security representative?

Who is responsible for work protection and safety at work?

Are devices for work protection in use, such as fall protection, working platforms, etc.?

What are the rules for personal protection (e.g. protective clothing)?

Where are the sanitary respectively health care facilities, how is first aid organized?

How is the construction site protected from external access?

General Impression of the Construction Site and Workplace

General impression of order and cleanliness	
Construction site installation/facilities	
Impression of construction material storage methods	
Impression of the various working processes	

Additional Remarks

Dialogue Partner

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