



RELEVANT CODES AND REGULATIONS: EFFECTS ON THE DESIGN OF INDUSTRIAL CONSTRUCTION

Ahmed Abdallah

*Dissertation Supervisor for British Columbia Institute of Technology (BCIT), Canada
Construction Management Program in conjunction with the University of Bath, UK
E-mail: Dr_ahmedabdelhamid@yahoo.com*

Received 23 April 2007; accepted 10 September 2007

Abstract. This paper presents the possible effects and restrictions that may arise in the field of industrial construction due to compliance with relevant construction codes and regulations, as well as the ways they can be favourably handled in the design of industrial buildings. Designs should be based primarily on human design factors, while considering the human as the centre of the work environment. Design parameters should be described as a function of both the physical and psychosocial attributes of a person as well as the technical and economical aspects in the design of industrial construction. This paper is an examination of the connection that exists between design law (codes and regulations) and industrial construction. The relevant construction laws and regulations are described, including standards and codes of practice that designing and supervising engineers are obliged to observe. Possible solutions and consequences of development in the production, constructional, and ergonomic field of design are also discussed.

Keywords: construction codes and regulations, economical, industrial construction design.

1. Introduction

New technologies have and will increasingly cause drastic changes in the range of operational funds, buildings and in human life. Any modern enterprise should consider the larger meaning of work quality and a working environment. It should additionally promote the abilities of the employee and identify with the project and/or product. In industrial construction it is generally accepted that enterprises are also understood in terms of a social system. The project needs to show a profit, but not at the cost of the health and safety of human beings. Summarised below are factors that influence industrial building and involve:

requirements of the socio-cultural situation, this may also consider ecological consciousness;

new manufacturing technologies and labour organization forms, such as: the employment of microelectronics, including artificial intelligence, requirements for product dimensions and their sensitivity etc. Other important factors are: the continuing increase in the education level of the population, the effect of work on the quality of life, effects on the natural environment, and increased ecological consciousness. Communication and human relations: in industry, labour is not seen as simply a factor of production, but more as human beings with specific demands that go beyond those of a component of a machine who can be replaced. An enterprise should recognise that the organi-

sation of the work, as well as the work environment, should contribute to profit but should also develop the social and emotional well-being of the persons employed. According to building regulations, civil rights of an owner entitle the owner to leave a building in its present condition or to develop it as necessary. This is known as construction liberty. This construction liberty is in the public interest as well as the protection of neighbours and is restricted both by the law and works management. This creates a multiple interest issue and requires a grant from the building authority. It must also include protective regulations that direct the enterprise to ensure a suitable work environment based on modernised health and safety regulations [1].

2. Requirements functioning against the enterprises

Government regulation requires that employers take measures to protect their employees through the consideration of certain general principles:

1. The avoidance of risks.
2. An estimation of unavoidable risks.
3. Danger at the source/location.
4. Consideration for fellow employees. This applies not only to the ergonomic organisation, but also to the work and manufacturing method (eg monotonous work, machine-certain rhythm).

5. Awareness and consideration for state-of-the-art.
6. An elimination and/or reduction of dangers.
7. The planning of work hazard mitigation measures with the goal of coherently linking technology, labour organisation, and working conditions, social relations and environmental influences on the job.
8. A collective and individual protection from danger.
9. Provision of suitable instructions provided to employees.

3. Local space planning

Under local space planning one understands generally the space planning on the district level. However, under local space planning any spatial planning for area units are subordinate to the municipal planning authority. A building permit is only granted when all legal conditions are met. The grant is given if the project corresponds to building code regulations in regard to kind, situations, form and use. Moreover, it should not contradict a surface dedication plan, a developmental plan and other public interests, especially security, health, traffic, tourism, the protected landscapes, local concerns and the protection of monuments. The building authority must first decide whether the property for land development is suitable. The answer to this question is decided in their own procedure after some building codes are reviewed.

Structural ranges and their consequences for development

The location choice is one of the most important conditions for the vitality of an enterprise, and the basis of existence of an individual citizen and the affects on the municipality. The land development concept contains the total plan of an industrial plant. This includes the buildings uses and ranges, main traffic routes, registered disposal systems as well as proximity by property. The result is documented in the general development plan and these are illustrated in individual sections. The design of the construction and the different uses are accommodated in one or more buildings. The organisation range internal development deals with the traffic routes, courses, doors and gates, staircases, escalators, pre-arranged escape routes, elevators, loading ramps and building hatches. The internal development system also deals with how the different buildings are connected with regard to the movement of people and goods; this could be done either vertically or horizontally. The elements of an organisation must be functional and their constructional design must meet the respective demands from the inside and outside. Considerations of plumbing, utilities supply, fire-extinguishing equipment, garbage and waste plants, kitchen plants, heavy and weak current plants, lighting systems, heat supply plants, ventilation and air conditioning systems as well as dust extracting installations are very important. Therefore the employment of technical plants for production with a higher technology constantly increases the influence of the building engineering on the design and construction plays an ever more meaningful role.

4. Requirements suitable for human work organisation and their effects on the industrial building draft

Requirements are placed ever more frequently on a more suitable working atmosphere, so that the satisfaction and the well-being of employees are strengthened. The organisation with the industrial building draft is of great importance. The progress in technology, in economic and in social ranges continuously influences the organisation of the industrial building. Important criteria include feasibility, stability and employee well-being. Organisations support the mental and physical well-being of employees, as well as promoting professional development, motivation and good health. Operational, structural and ergonomic organisation ranges must be placed under these aforementioned criteria for a suitable working atmosphere, which will consequently and naturally lead to structural development.

4.1. Operational organisation ranges and their consequences for structural development

The operational organisation falls under the organisation range of the product. The choice of the product and working conditions are largely predetermined by the organisation. The building and operational funds have a substantial influence on preliminary decisions, also belonging to the technology range of the organisation. New requirements affect the industrial building as new technologies emerge. This requires that flexible production systems be installed. Further, the organisation range operational funds will have a substantial influence on the organisation of the industrial building eg the boundary conditions for the techno-organisational organisation become fixed by the choice of the operational funds etc. Machine dimensions are to be considered in area requirements, the machine weight with the construction of the building; the foundations are to be determined based on the resulting loads. In the future, personnel will be required to take into account both the classification of rooms and changes to be made.

4.2. Organisation

The organisation regulates the relations between humans and the operational funds. The success of the operation depends on all groups working cooperatively to achieve their goals:

1. Techno-organisational organisation marks the cooperation of the operational funds: production method (single, series, mass production), manufacturing structure (rows, direction structure), manufacturing form (workshop, groups, flow production), mechanisation degree (individual performing on machines, therefore easement of the manual work), degree of automation (ie how automation is carried out and its effect on employees).

2. Socio-organisational organisation

People feel the effects of the organisation. The importance is that it coordinates its needs, receives all necessary information in order to do its work, and possesses a plan of action for implementation. Abilities and difficulties must

be considered. Cooperation will be influenced by leadership style which is either authoritarian or participative. The techno-organisational organisation criteria have a substantial influence on the arrangement of the operational funds and on jobs. Following clarification, the requirements are: the room size, distances, the construction system (wing unit, cover, and soil), the building services (disposal of the operational funds etc) are defined, and important conditions, such as support rosters and room heights, are specified.

5. Legal obligations to traffic development and building site safety

Building site safety is regulated in accordance to traffic, such as construction equipment (bulldozers etc), public thoroughfare (pedestrians and drivers). Safety devices, such as disposal shoots, barricades and warning signs etc, must be implemented. In addition to the mentioned safety de-

VICES, other necessary measures must be taken to prevent hazards. Care is to be taken so that concern for the rights of pedestrians is shown. A covered pedestrian walkway on construction sites is demonstrated in Fig 1.

- closed boards,
- wire and plastic networks,
- slats,
- reinforced steel mats establishing safety for pedestrians within range of site may be necessary [2].

Routing of traffic within the building site and building employee protection regulation:

- keep free of obstacles and wastes,
- protection from falling articles,
- protective cover,
- clear visibility of entrance and exit signs.

An example of building site traffic management mechanisms is demonstrated in Fig 2.

- safety device of building sites, traffic rule plan.

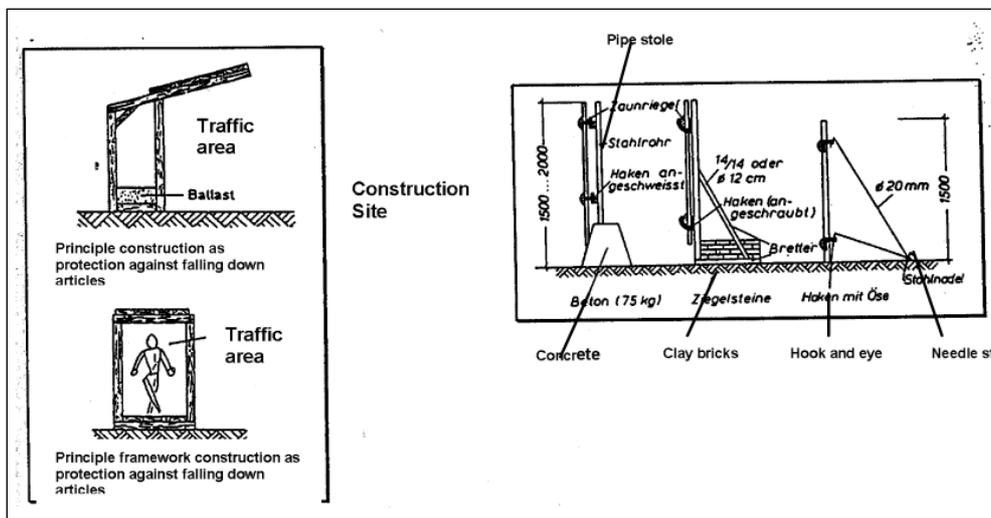


Fig 1. A covered pedestrian path on construction sites

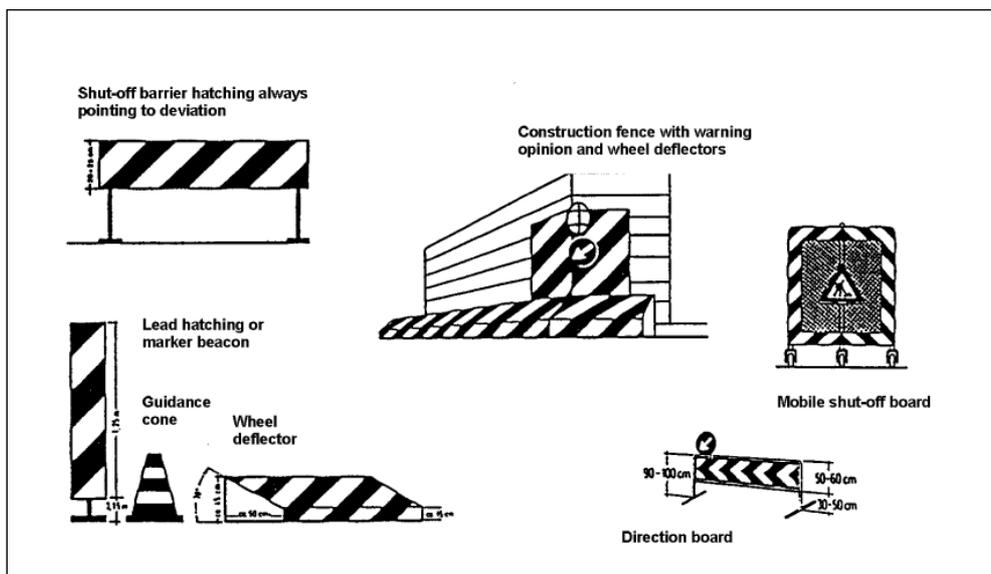


Fig 2. Building site traffic management mechanisms

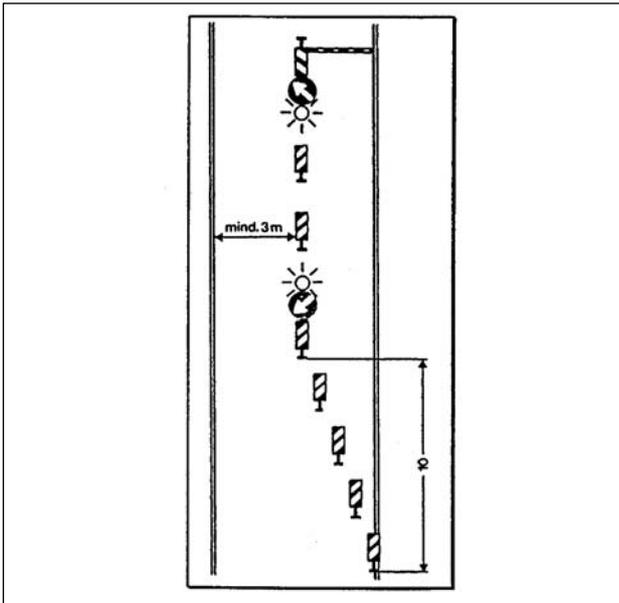


Fig 3. A general rule plan of safety device on building sites

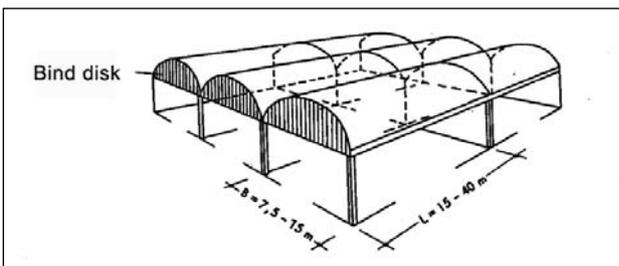


Fig 4. Single-arched shell construction: transverse tons, proportion of the spans

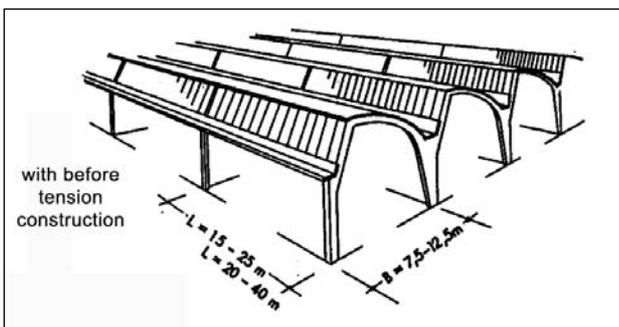


Fig 5. A saw-tooth roof with suitable window band, each unit is individually supported

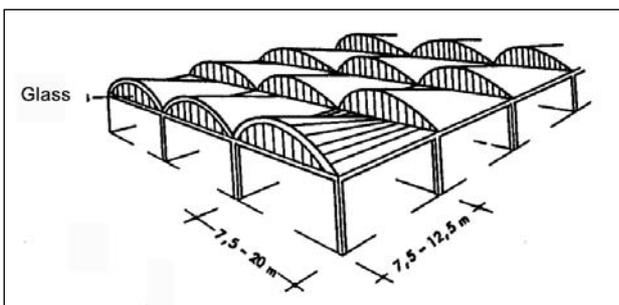


Fig 6. Conical shell with a grader boundary as the tie rod

Within the turning range beacon/guidance cones are estimated per/m misalignment

- in the traffic bottleneck beacon/guidance cones per 30 m,
- light security, with a light illumination of min. 180 mm,
- white passes to right,
- red passes to left,
- yellow is a general warning light and direction is by a red light.

A general rule plan of safety device on building sites is illustrated in Fig 3.

6. Production department

For the use range of production, essentially three building types exist: low-rise buildings, hall constructions and multistory buildings. Distinction criteria such as the sketch and building cross-section are affected by various requirements and determined for selection.

1. Low-rise buildings permit a relatively good utilisation of property, the arrangement of the operational funds in one level, as well as the easy conversion and accessibility of the operational funds. The basic forms, which are used in the industrial building, are: low-rise building with horizontal and/or bent roof-spatial framework, low-rise building from barrel-vault shells, low-rise building from conical-flat reinforced concrete.

2. Hall constructions are typical of industrial buildings. Elevator dimensions with a pronounced longitudinal development are required for technical reasons. The static structure of resounding permits different possibilities. The choice of the system hangs off the spans, the crane equipment, establishment conditions and the building materials. In addition, the question of a later extension of one resound is the influence of static structure. Single-arched shell construction: transverse tons, proportion of the spans are shown in Fig 4.

3. Many jobs can be accommodated in multistory buildings. Vertical transport of materials is much easier than stairs. The loads cannot be too large, therefore several loads may be required to be transported. A resound is usually made of individual binders. Resounding can be an arc-shaped training of the cross-section when the bending tensions are reduced, which is even better when widespread reinforced concrete resounding is used. The resounding is often high-lyed for lighting and technical reasons and across the side unit. The wing unit of an industrial hall develops primarily from a functional necessity; however, always with a form associated with its area and shape. A saw-tooth roof with a suitable window band, each unit is individually supported as shown in Fig 5. Even if the wing unit should be more or less veiled later by extension elements and installations, obtain the area formed by the wing unit, eg a low-rise building with straight, horizontal binders rather as oppressive and orientation less, as one resound with elbow binders. A conical shell with a grader boundary as the tie rod is shown in Fig 6.

6.1. Research and development range

If the appropriate surface of the research range cannot be accommodated in independent buildings, then space must be provided in other buildings with other use ranges. Most buildings of this kind (laboratory area, technical etc) are subject to special functional requirements and monitoring regulations and therefore they are generally used conditionally. Structural development is characterised by a high degree in installations by most different media (such as gases, chemicals etc).

6.2. Supply and disposal range

All industrial companies need buildings for supply and disposal, in which the delivery of media from the public net takes place and or materials for the special company-owned use are prepared. These areas and plants are mostly integrated as cultivations, basements or roof systems in buildings of other use. Otherwise they are accommodated in separate objects, flat or hall constructions. In this case there are fewer employees required because of electronic measuring and automatic control. The following functions are to be assigned to supply and disposal range:

1. The heating system of an industrial company usually consists of plants for heat production, piping and heating surfaces. The power supply of the enterprise will provide sufficient heat for the plants. The heating enterprise must be safe, sufficient for hygienic requirements and cause no improper loads.
2. Operations rooms are considered to contain current supply transformer stations as final electrical and business premises. The areas with transformers in those should as be accessible as possible for transport, operation and fire fighting.
3. The water supply to an industrial company is of great importance, particularly in connection with fire fighting. Water supply through an elevated tank connected to a local pipeline is essential.
4. Wastewater treatment. The building of company-owned purification plants should be close, if wastewater in such quantities results or exhibits contamination drains into a nearby stream a company-owned purification plant should be nearby. The choice of the system that can be used depends on the quantity and the kind of the wastewater resulting from the enterprise. Also the possibility must be examined, in which released wastewater could be recycled, (eg use as cooling water) [3].

6.3. Work entrance

The work entrance is the interface between the industrial company and the system of the public traffic routes. At traffic streams, one differentiates in this way:

- persons employed,
- visitors,
- goods.

The function of the work entrance lies in a smooth arrangement (separated from pedestrian and vehicular traf-

fic) and derivative of these traffic streams. The gatekeeper's administrative centre could be located here.

7. Ergonomic organisation ranges and their consequences for structural development

Ergonomics is the study of persons in their working environment. It analyses human efficiency and maximum stress levels and appropriate measures within the organisation that need to be taken for an adjustment of and for the effect this may have on the employees. It examines the biological and psychological conditions regarding the relationship between humans and technology. The possibilities of the work place layout as well as the environmental influences are almost completely determined by structural conditions. Room climate, room air, colours, lighting (both natural exposure and artificial) etc will play a vital part in ergonomic requirements and consequently make more suitable working conditions [4].

7.1. Work environment

In order to meet the ergonomic requirements of the job, special attention must be paid during the building design and organisation to the following points:

- a) space and area requirements;
- b) arrangement of the jobs;
- c) flexibility.

The space requirement depends on the area requirements, and the required room size is dependent on minimum values for the light room height. The determination of area requirements are to be included in the operational fund, including operating areas as well as individual working areas. In addition, preventive measures and safety margins are to be taken into account. The floor space is sufficient for each employee if at least 2 m² connected unadjusted floor space is present in direct connection with the job or indirect proximity. The soil must be stumble resistant and must exhibit a slip free surface. In the reference to the safety margin the danger places are to be secured in such a way that access to dangerous areas are prohibited.

Safety margins and protected zones are specified as follows in most Labour Protection Regulations: The operational fund surface is specified not only by the form and size of operational funds, but also by its function. Serving machines must have sufficient space, easy accessibility and proper safety mechanisms. The workbench is correct if it exhibits the required form and height. If one works with dangerous working materials, the surface of the workbench must be clean and free of obstructions. Areas where jobs are highly automated and where transport and material handling are completely automated must be secured from an unintended entry. When the conventional production area is in the planning process, attention is to be paid to the creation of possibilities both for formal and informal communication. A good possibility of communication represents the delivery of the work articles (work-pieces), if it takes place via the operating personnel. Changes in the enterprise such as renovations, extension, modernisation, rationalisation or automation, must not lead to bottlenecks, unfa-

vourable flow of materials or negative working conditions for the employee. Therefore in planning there must be flexibility in transport storage as well as all uses of an industrial building.

7.2. Room climate

The climate is a comprehensive term for all physical factors, which affect the heat exchange between bodies and environment. Affecting factors are:

Air temperature, humidity and movement, ie air speed, contributes to the comfort level. Therefore both air, temperature and middle radiation temperature must be considered. If the radiation-temperature of a surface and/or a source of radiant heat deviate substantially from the ambient temperature, a radiant heat measurement is required in °C. With work of small physical demand the ambient temperature should be 19–25 °C. With work with a relatively normal physical demand the ambient temperature should be 18–24 °C. With work with a relatively strong physical demand, the ambient temperature should not be below 12 °C. In reference to the air space the following is to be considered. For each employee in a closed area, depending upon weight of the work, an air space of 12–18 m³ must be available. At least 12 more m³/employee for work with a small physical demand and at least 15 more m³/employee for work with normal physical demand. At least 18 more m³/employee with work with strong physical demand and/or with difficult working conditions such as heat, air pollution etc. If additional persons (eg customers) are present, the indicated values should be increased by at least 10 m³ per person in each case. Possible installations such as furniture must be considered. The relative air humidity is a measure for the water vapour quantity of air in the comparison to the maximum possible water vapour quantity. It is measured with an aspiration Pyrometer, hair hygrometer or an electrical hygrometer, with data in percentage. With work of small, normal and strong physical demand the air humidity between 30 and 70 %, with air conditioning systems between 40 and 70 % is required. Air speed, speed with which air flows by the area is measured with an anemometer; the values are indicated in m/sec. With work of a small physical demand air speed max should be 0,10 m/sec. With work of normal physical demand air speed max should be 0,20 m/sec. With work of strong physical demand air speed should not be felt unpleasant [5].

7.3. Ventilation of workspaces

In workspaces, it should be ensured that air is supplied as free of impurities as possible. Air of small oxygen content and high carbon dioxide content must be exhausted. The ventilation must take place in such a way that the areas are ventilated as evenly as possible. In case of an artificial ventilation when for one hour, the employee works with a small physical demand, a fresh air quantity is at least 35 m³ supply; with work of normal physical demand, a fresh air quantity of at least 50 m³, with work of strong physical demand a fresh air quantity of at least 70 m³ is required for everyone in a work space constantly employed. For more difficult

conditions of work, like increased thermal effect, these fresh air quantities must be higher by at least a third [5].

7.4. External sun protection

Advantages with external sun protection: if optimal heat rejection is demanded with an unhindered view and glare-free daylight conditions, then most likely the mainly effective method would be that which would interrupt the Sun beams before they come at all into contact with the glass (windows). The sun protective systems illustrated above come in two variants: with forms and z-shaped lamellas from high-quality aluminium. At the solarium, above the windows as horizontal out collar element installed, the Sun beams are intercepted directly by shadow at the exterior of building and permit, at the same time, a completely free daylight entrance. With heater/ventilation and air conditioning attention is to be paid to the different heating/cooling load of differently oriented building parts (south side sun / north side shady), allowing the temperature to be more easily regulated.

Appropriate thermal insulation, heat storage, diffusion security, proper ventilation and artificial air humidification can help avoid overheating. In order to yield productive results, the employee must feel comfortable in his work area. Therefore, apart from the conditions of the work activity and clothes, the climatic criteria stated above must be fulfilled.

8. Lighting

Light belongs, in the physical sense, to the electromagnetic radiation. It spreads in the form of electromagnetic waves and thereby transports energy. The light related energy has a great importance for lighting the areas and for the energy balance of daylight and artificial light. Daylight differs from the artificial light by the fact that the source of light lies outside of the building and cannot be controlled. The balance of daylight and artificial light is necessary in many areas, in order to illuminate sectors without windows continuously [3].

8.1. Natural exposure

Working places in buildings must receive as much natural light as possible. They should be equipped with mechanisms to provide for both the security and health of the employee, and sufficient artificial lighting must also be provided where required.

8.2. Exposure in work spaces

Work spaces must, as far as the kind of job or the purpose of the area does not oppose, include free light entrance surfaces, (such as windows, upper-light or domes), whose coverage area must include at least one tenth of the floor surface of the work space. Workspaces must as evenly as possible be naturally exposed to light. Light entrance surfaces must be so constituted that unfavourable effects of direct sunlight are avoided.

8.3. Artificial lighting of the workspaces

Lighting mechanisms must also be arranged and procured to minimise the disturbing direct influence of light on the eyes. Reflected glare, flares and stroboscopic effects must be avoided. Necessary lighting mechanisms must also be installed so that no falsification of colour arises.

9. Daylight lighting

Handling daylight is indispensable. In the advanced cultures, from Egypt to Greece, from Mesopotamia to India, the daylight is optimally used. During the building design, the openings in the fronts are placed and not only to create an appealing appearance but to skillfully utilise the light steering element and spatial atmosphere. The principal reason for the preference of daylight in comparison to artificial light lies in the presence of light entrance openings, above all side windows, and upper-light, which pleasingly maintain contact with the external world.

Usually the beam of light through windows is not sufficient. The clearing radius and light intensity are limited with vertical light at the front of premises. In contrast, the light intensity through the roof openings is approx a fivefold higher than that with windows. The following illustration shows an attractive hall construction; one with a daylight thoroughly-flooded exhibition hall and this place offers space for hundreds of automobiles. It covers a total area of approx with its external dimensions of 42×82 m – without counter bearing – 2800 m². In the rear, part resounds are positioned in 3 cultivations the office space as well as the requirement of social and secondary rooms. A fire-proof ventilated saddle roof makes an excellent use of natural light. (Bright daylight fills an exhibition hall which is capable of holding hundreds of automobiles, demonstrated in Fig 7) [6].

The German standard (DIN 5034) recommendation regarding the interior lighting with daylight is published. The steering element of daylight is an important part of planning and arranging the way sunlight reaches the areas; it cannot reach in a natural way. Since daylight is not a constant source of light, due to day-night cycle and climatic variations, it is possible to use artificial lighting [6].

10. European environmental awareness

Environmental awareness is clearly more strongly pronounced in Central Europe than in the South of the continent. Pioneering roles have been played in particular by Austria and Germany and partly by the Netherlands. The intensity of the legal regulations also corresponds to that extent. The EU provided the member states with a guideline for environmental compatibility in 1985 and guidelines, which must be taken during the permission of relevant building projects, which must be considered by any industrial enterprise. For the companies in the European common market, a building product guideline and a building coordination guideline were also introduced. These include requirements for hygiene, health and environmental protec-



Fig 7. A fire-proof ventilated saddle roof makes an excellent use of natural light

tion. These guidelines were also stipulated to be the basis for all legal regulations and standards in the future. A further basis was the European Charter of environment and health, which was accepted in December 1989 by 29 states. Forerunners are guidelines of the World Health Organisation (WHO), which referred promptly to the rights of humans to physical, mental and social well-being. A large number of laws, guidelines and standards for protecting the vegetation, soil, water and air as well as people, have since been implemented in the European jurisdiction.

11. Conclusion

In summary, it is shown that the effects of the relevant construction laws in the field of industrial constructions do not mean a restriction of the designing liberty, but rather that specialists should be led to exhaust the possibilities to create a human world of work and a humane work environment.

The goal of the detailed treatment of the topic specified above is not the legal explanation, but a practical conversion of specific laws. Thus the question arises, how can a suitable human working sphere organisation under the relevant construction laws be converted into an industrial construction? The implementation of this goal requires teamwork, particularly between architects and civil engineers, from design to construction. In the context of the organisation, industrial building consideration has to be taken based on two factors: human and type of work. The civil engineer cannot carry out this task alone; therefore cooperation of the specialists taking part in the planning and building process is almost compellingly necessary as a group and/or team, in order to achieve a generally satisfying result. This result is in the long run a humane job, where humans have to implement a certain type of work in the context of industrial production.

References

1. ABDALLAH, A.; SOMMER, D. *Relevant construction laws for the industrial construction and their possible effects on design of industrial construction*. Thesis implemented at Institute of Building Construction and Industrial Architecture

- of faculty of Civil Engineering at Technical University of Vienna, Austria, 1995.
2. JODL, H. Mechanism & enterprise of building sites, study sheet No III, TU Vienna, 1995.
 3. *Building code for Vienna, Viennese the building law*, Vol 1, 1986.
 4. SOMMER, D.; WOJDA, F. *Industrial building - suggestions for code-signing*. Publishing house of the OEGB, 1987.
 5. GRUBITZSCH, S.; REXILIUS, G. *Psychological fundamental ideas, encyclopedia, seize, Holling*. N. Work and organization, 1990.
 6. SPLENDOR, K. *Light and spatial arrangement*. Publishing house C. F. Mueller, Heidelberg technical periodical: Industrial building, 5 Sept 38. Class, 1992.

SPECIALIŲ ĮSTATYMŲ IR REGLAMENTŲ ĮTAKA PRAMONINIŲ PASTATŲ PROJEKTAVIMUI

A. Abdallah

Santrauka

Šiame straipsnyje aprašomi galimi padariniai ir suvaržymai, kurie gali atsirasti pramoninių pastatų statyboje laikantis atitinkamų statybos įstatymų ir reglamentų, taip pat būdai, kuriuos galima būti tinkamai pritaikyti pramoninei statybai projektuoti. Projektuose visų pirma turi būti atsižvelgiama į žmogiškuosius veiksnius, žmogų laikant darbo aplinkos branduoliu. Projekto rodikliai turi būti apibūdinami funkcija, priklausančia nuo fizinių ir psichosocialinių asmens savybių, taip pat techninių ir ekonominių aspektų, darančių įtaką pramoninių pastatų projektiniams sprendimams. Šiame straipsnyje tiriamos sąsajos tarp projektavimo normų ir pramoninės statybos pavyzdžių. Aprašyti su statyba susiję teisės aktai ir reglamentai, taip pat tie, kurių turi laikytis projektuotojai ir statytojai. Straipsnyje taip pat svarstomi projektavimo patobulinimai gamybiniu, konstrukciniu, ergonominiu aspektais.

Reikšminiai žodžiai: statybos įstatymai ir reglamentai, ekonominis pramoninių pastatų projektavimas.

Ahmed ABDALLAH. Doctor, Dissertation Supervisor for British Columbia Institute of Technology (BCIT) Canada, Construction Management Program in conjunction with the University of Bath, UK (2004 – Present). Master of Science (1996) in Civil Engineering, Department of Construction Management and Engineering Economics, Technical University of Vienna, Austria. Doctor of Science (1999) Technical University of Vienna, Austria. Postdoctoral fellow 2000 at The University of Western Ontario, London, Ontario, Canada, Department of Civil and Environmental Engineering, Research Associate, research for rock mass grading, tunnelling techniques, prefabricated concrete, etc., Author of multi-tude articles include presenting at several international conferences. Member of the American Society of Civil Engineers and reviewer for their Journal. Research interest in the areas of analysis, investigation design and management of buried infrastructure systems. Other research interests include: productivity, risk assessment, reduction of overall life-cycle costs, Project Management, Organization, selection and purchase recommendations of earthmoving equipment, ground behaviors, scheduling, cost estimation and control, planning and resource management, cost and value analysis, commercial, procurement and strategic management.