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Design Approach with Respect to Durability

Approche de projet en vue d'une bonne durabilité

Bemessungsvorgehen zur Gewährleistung einer hohen Dauerhaftigkeit

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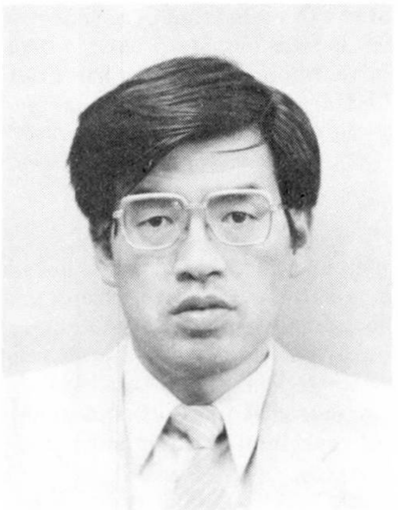

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SUMMARY

The present report deals with a case study of realization of design specification with respect to durability on a medical and welfare complex for the aged. Various kinds of durability damage for the life span should be analyzed and synthesized to develop design specifications architecturally, structurally and environmentally which can be successfully accomplished at construction sites.

RÉSUMÉ

Ce rapport concerne le projet relatif à un complexe de soins hospitaliers, pour personnes agées, la conception étant soumise aux conditions imposés non seulement par la construction mais aussi par l'environnement, du point du vue de la durabilité et de la maintenance. Les dommages éventuels, tels que déformation des planchers, altération des revêtements de sol, neutralisation du béton, infiltration des parois, dilatation ou resserrement des joints, ont fait prévoir un ensemble de dispositions visant, au niveau même de la construction, à satisfaire aux tests de contrôle de la qualité.

ZUSAMMENFASSUNG

Dieser Beitrag behandelt eine Fallstudie für die Ausschreibungsbedingungen eines Seniorenheimes im Hinblick auf die Dauerhaftigkeit. Verschiedene Arten von Alterungsschädigungen sind abzuklären, um den Entwurf bezüglich architektonischen und ingenieurmässigen Anforderungen derart zu verbessern, dass die Dauerhaftigkeit durch die Ausführungskontrollen gewährleistet werden kann.

1. INTRODUCTION

Durability of buildings is related to various kinds of complicated characteristics including traditional construction technology and material, the climate of temperature, humidity, wind and sunshine quantity at the construction site, various type of loading, particularly due to natural causes such as earthquake or typhoon, and client attitude toward maintenance after completion. Thus, reinforced concrete buildings(RC) should be designed and constructed in terms of these factors architecturally, structurally and environmentally. Damages of concrete building due to durability over its life span in Japan should be divided into three categories of loading of earthquakes, of non-structural members such as finishment or facement appeared naturally or artificially and of serviceability including environmental equipments, change of occupancy and architectural deterioration. Particularly Japanese seems sensitive to this architectural deterioration to a large extent, which should be predicted at an early stage of project. Generally the climate of Japan has distinct four seasons with arid, cold winter and humid, hot summer. Traditionally people has enjoyed their life under beautiful cherry blossoms in spring, a hazy moon in autumn, even cicada sound of hot summer in rapport with the nature in which people would like to die after aging. Historically Japanese architecture as a shelter, built on soft soil layers or alluvium, has been reflected conformity to the nature, including, positively, these beautiful seasons and, negatively, strong earthquake or typhoon. Furthermore, because of dense urban area due to recent economic growth landownership demands more complicated restrictions on almost all projects. If traditional shelters, which is made of wood, could resist severe cold winter, life of remaining seasons should be comfortable with aid of breeze. After the war a large number of concrete shelters appear and not necessarily conform to the traditional Japanese mind architecturally and environmentally. Consequently, it is necessary to develop more sophisticated design and technology in conformity to the nature and human behavior with respect of durability of concrete shelter over its life span.

The present report deals with a case study of realization of design method of durability on a medical and welfare complex for the aged which locates outside Nagoya where it is hot and stick in summer, and cold and windy in winter and furthermore sometimes has heavy rain. Concrete buildings in the complex should resist disastrous loadings of strong earthquake and typhoon structurally and the natural climate environmentally and architecturally[1],[2].

2. PRESENT COMPLEX

This private medical and welfare complex for the aged holds 200 beds and consists of three RC wings, namely, a medical clinic, two nursing homes and a day-care center as shown in Fig. 1. Various kinds of restriction surrounding this project demand more sophisticated design review not only structurally but also environmentally or even architecturally particularly of durability closely correlated to maintenance for the life span. Prominent properties are as follows.

Location : a coastal city outside Nagoya with 300 thousand population,
surroundings : faced a national route of considerable traffic noise, vibration and air pollution,
on alluvium or soft soil layers,
climate : temperature of $-2°C \sim 32°C$,
humidity of 50% $\sim$ 95%, occasional coastal wind and heavy rain,
facilities : a medical clinic (two story RC),
nursing homes (three story RC) and a day care center (one story RC),
including various equipments (solar panel, heating, cooling, sprinkler systems).

Hence, the design and construction should be accomplished against durability of these properties in harmony with the financial requirements.

3. DURABILITY DEFECT

This type of RC buildings, which is popular in Japan, are frequently built in dense urban area on alluvium certainly subjected to strong earthquake for their life span thus indispensably resulting the choice of appropriate piling foundation and anti- seismic walls in frame, which is controlled by regional structural regulation and code which can narrow diversity of durability with respect to safety against loading to satisfactory extent. Durability damages concerning to architectural details including cladding and finishment has diversity similarly to equipment system, which are closely related to maintenance by the clients for the life span of building. From a recent investigation[3] ill-conditions

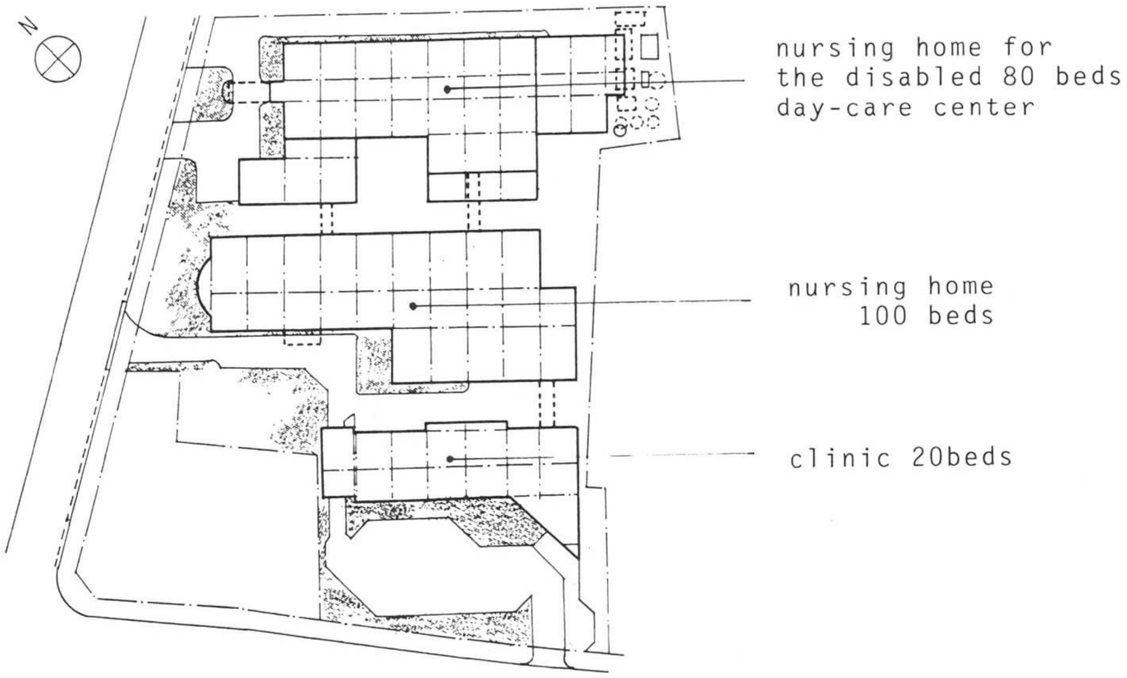

Fig. 1a Site plan of the complex

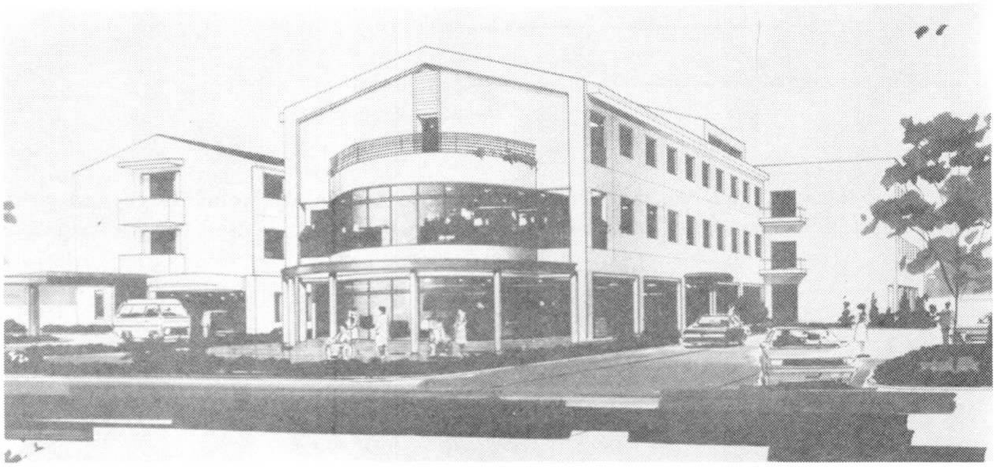

Fig. 1b Perspective of wings

due to a lack of durability can be classified in order of number of causes as follows.

ill-condition due to durability
- materials
- waters(rain, leak of equipment and pipe)
- strength of materials
- deterioration by aging
- form and size
- application
- noise and vibration
- temperature
- electricity and RI
- coloring
- miscellaneous

These ill-conditions can be extended into actual defects in detail which should be more practically evaluated at design specification and construction.

- defect
  - leaking
    - roof
      - water proofing materials
      - slope
      - flashing
      - number of roof drain
      - over-flow
      - pitched roof
    - exterior wall
      - intentional cracks
      - sealing materials
      - embeded pipe diameter $\leq \frac{1}{5} \times D$
      - coverage of pipe$\geq 30mm$
    - piping
      - leak of oil or gas
      - anti-errosion
  - dewing
    - roof
      - heat insulation, thickness
      - domain
    - exterior wall
      - heat insulation, thickness
      - domain
    - window
      - waste of dewing
      - heat insulation of frame
    - humid area
      - ventilation
      - air duct
      - heat insulation of pipe
  - wall-off
    - tiling
    - cornering
  - fire proof
    - spreading(grease trap)
    - ducting
  - settlement
    - porch slab
    - adjoining pipe
    - embeding

Furthermore, thus classified defects can be deployed more concretely from design and construction point of view. The following is an example of cracks which will be prevented as strictly as possible at each job stage.

- concrete cracking
  - design specification
    - exterior wall
      - intentional crack
      - wall thickness
      - reinforcement, a_t
      - diagonal reinforcement
      - opening crack
      - piping
    - roof, eaves
      - reinforcing
      - diagonal reinforcing
      - intentional crack
  - ready mixed concrete
    - mixture
      - slump
      - water cement ratio
    - material
      - normal
      - AE
  - concreting
    - amount per day
    - humid curing

As a result these categorical characteristics on durability are strongly correlated to each other which is, however, difficult to evaluate its priority precisely. When these characteristics are asserted as a database of AI technology, which consists of facts and rules, it becomes rather easy to search an optimal path to any durability goal by means of declarative languages such as Prolog which has versatility of backtracking manipulation. Herein, on an personal computer effective rules are asserted by Prolog.

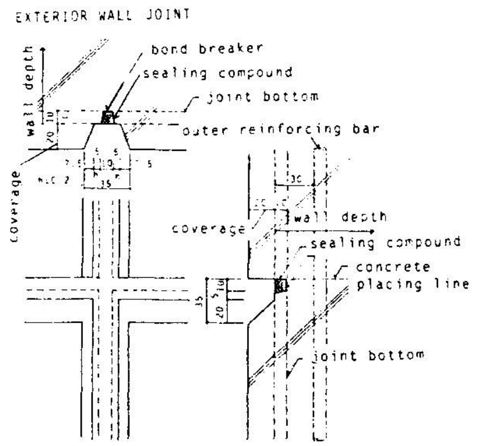

Fig. 2a Exterior wall joint

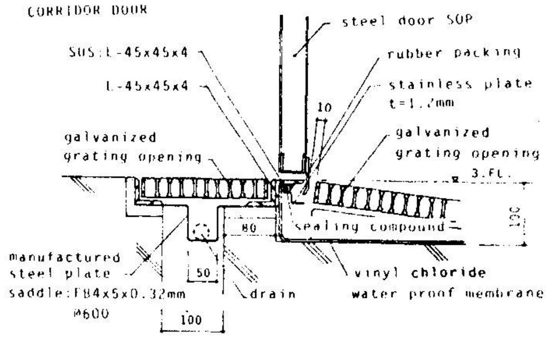

Fig. 2b Corridor door

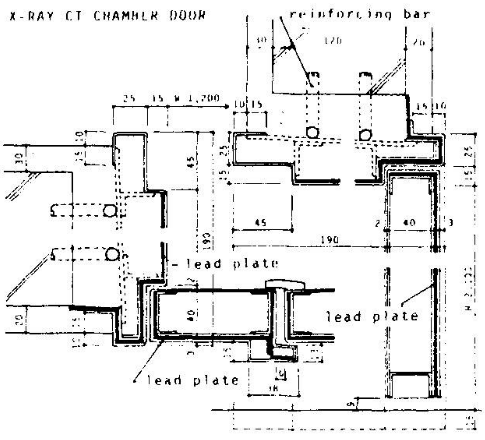

Fig. 2c X-ray CT chamber door

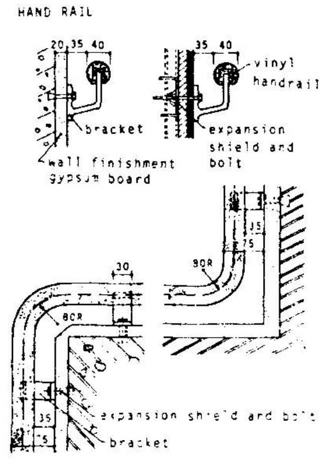

Fig. 2d Handrail

4. DESIGN SPECIFICATION

Although the occurrence of durability defects should be avoided as strongly as possible particularly after completion, an architecture should also original and beautiful itself. Thus creation of idea must be flexible with consideration of the restriction of durability. It is necessary to develop more rational details as the design specification to the construction site with reasonable investment. The design specification should be an understandable description of necessary information.

Fig. 2 shows several examples of details developed relating to durability defects. Furthermore, these details should be translated into field information for workers who will appreciate and realize by means of TQC.

5. REALIZATION BY TQC

From the investigation on durability of various RC buildings, damages concerned with construction process are due to the following reasons, namely, uncertain information of design specification to the construction field and a lack of appropriate construction technique. Particularly, on the latter there is a large technological diversity among workers and technicians at the site whose traditional skills become to decline as economical growth. It is necessary to develop a more progressed approach or an alternative to synthesize these unlevel skills to attain the prescribed durability tolerance.

To accomplish a certain level of quality control the traditional management or SQC (Statistical Quality Control) demands an inspection system, which tends to decrease productivity. Although a strict and large amount of inspection is accomplished there may appear oversights which causes durability defects particularly after completion. Hence, TQC (Total Quality Control) movement can be applied,

which means continuous quality control movement by QC circles at the site by all members particularly participated by workers who propose and devise various improvements on problems related to durability. TQC was originally developed in the industrial production process, and then prevailed extensively in the construction field successfully in Japan.
Concrete goals relevant to almost all kinds of field problems are discussed in QC groups including field workers and technicians at the construction site continuously. These group discussions are reflected to the construction process in progress. The construction industry of Japan has accepted this movement from the early seventies prevailing prominently nowadays. Presently the TQC is extended to even GWQC (Group Wide Quality Control). At the present construction site field workers including engineers accomplish the TQC movement to realize the durability tolerance specified by the prescribed design specifications. Many QC circles are established, each of which consists of several persons who belong to the same occupation. Each QC circle find an activity subject on durability from its surroundings, which is not necessarily sophisticated from the engineering point of view. Rather trivial problems to be improved at the site should be preferred, which QC circle participants analyze and discuss. The causes and results of subject are derived by means of interaction charts after discussion ordinarily for half an hour or less of several times on duty hours. This implies that a direct reflection of proposals by the field workers to concrete device of improvement can be accomplished. Naturally, these proposals are found through daily construction process and the results of their realization is compared to goal. This process is repeated until satisfactory level is attained. Thus, the realization of TQC is practically achieved for cost less than the required.

6. CONCLUDING REMARKS

Medium and low rise RC buildings, which are in the majority in Japan, reflect the social, economical situation with even sometimes chaotic contradictory results of durability demands including safety and deteriorations of architectural, environmental serviceability after completion. These durability demands should be realized and balanced not only engineeringly, architecturally but economically at each stage of design specification and then construction level. It is practical to make analysis and synthesis of durability by AI technology on a personal computer to arrange facts and rules with respect to damages. Thus obtained design specification is deployed at the construction site. However its reliable realization is not always easy because of unlevel skill of subcontract workers. TQC movement by these workers can ensure the realization at the site successfully and furthermore voluntarily. This process could be successfully applied to highly facilitied RC buildings of a medical and welfare complex for the aged to guarantee of balanced durability for life span.
Finally, the authors would like to thank Shimizu Corp. on this study.

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