Special Issue | Management of Emergency Epidemic Response Projects

△ Leishenshan Hospital © Ding Shuo

Upon the outbreak of COVID-19 in Wuhan in January 2020, Central-South Architectural Design Institute Co., Ltd. (CSADI) has been devoting itself to designing projects for epidemic fighting since January 24 (Chinese New Year's Eve), fulfilling its responsibilities as a state-owned enterprise. Its achievements included Leishenshan Hospital, several makeshift hospitals and isolation areas, two EPC makeshift hospitals, and conversion of ordinary hospitals, totaling 38 projects. **The Leishenshan Hospital was completed and accepted in 10 days and makeshift hospitals were finished in just 3 days — such "Chinese miracles" played a decisive role in combating COVID-19.** These emergency projects feature no specific floor area, no available design specifications, no clear function requirements, quick design and construction within tight period, and scientific planning and management of project while ensuring the structural, fire-fighting and environmental safety. **This article briefs the project management from three perspectives by taking the Leishenshan Hospital as an example.**

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I. Overall Control

At the beginning of Leishenshan Hospital Project, the major participants, including the client, design institute and general contractor, jointly set the targets and developed a Gantt chart — ***Construction Schedule of Leishenshan Hospital Project*** for strict observance by participants.

1. External communication: The major participants of Leishenshan Hospital Project made decisions together with other concerned parties such as the client, construction agent, contractors, key subcontractors, user, and O&M personnel of the hospital through collaboration, decision-making mechanisms, and meetings. In this manner, their needs and experience-based recommendations were incorporated into the conceptual design, thereby improving the design feasibility and meeting the O&M needs of the hospital user.

2. Design process: A special team was formed by senior designers from different disciplines, who were responsible for all service links in design, coordination and support. In addition to the personnel allocated based on the traditional four-level design process (**review, check, design and drawing**), one project manager and one project assistant were appointed to coordinate the work among professionals from different disciplines. Meanwhile, based on the above-mentioned Gantt chart, the project manager followed the construction schedule, went back to set the design schedule, **supervised and reviewed the implementation and completion of design tasks, handled the in-process design problems, developed corrective measures, and ensured the overall design progress**. As to the design quality control, in each discipline, chief architects and engineers engaged in overall control, while reviewers and checkers worked from the stage of conceptual design to ensure that designers can bring their professionalism into full play. They held project review meetings, expert consultation meetings, etc. during the design stage to identify and address problems in time for a smooth progress of the project. Moreover, reviewer and checkers, participating in all stages, were ready to settle matters that might arise from drawing, which effectively improved the design quality and shortened the time needed.

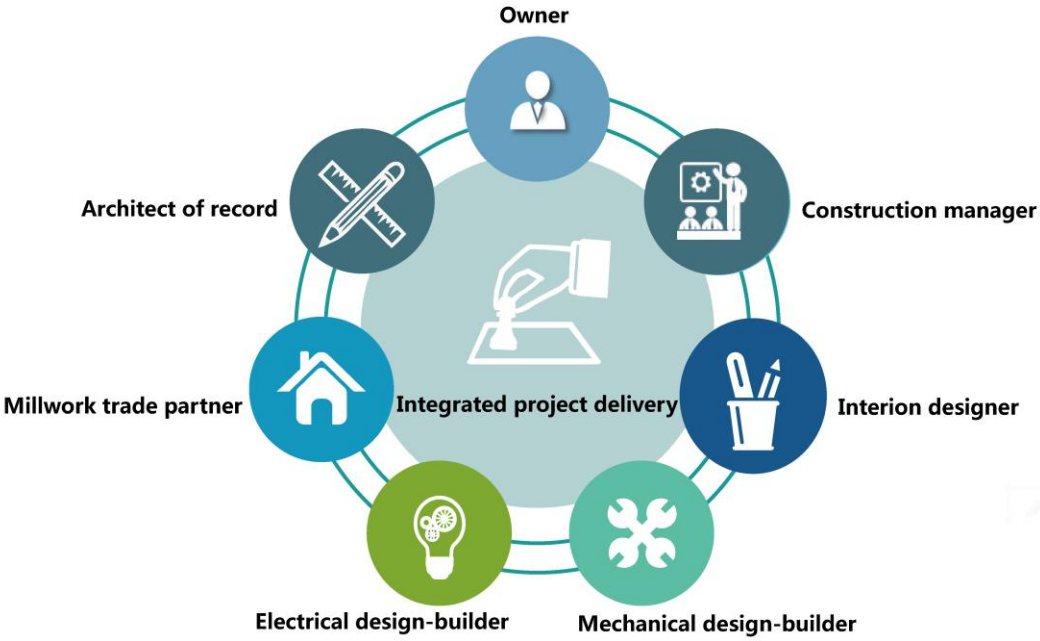
3. Construction cooperation: Given that the project had short design and construction period with big piles of drawings, once the construction starts rolling out, sufficient technical professionals covering all disciplines were ready onsite for communicating with the contractor, making disclosure of construction drawings, giving instructions, and handling sudden design changes, to avoid reworking resulted from the construction against regulations and meet the overall schedule of the project.

4. Response to hospital user's requirements: This special project featured strict requirements on the design of functional areas, patient and medical staff flows, lighting, ventilation, exhaust emission, sewage treatment, etc. In response to that, CSADI cooperated with universities or colleges and enterprises to research and analyze the key and difficult design issues and applied the results concerned to the design, so that the completed hospital meets the needs of the medical staff and the requirements on medical processes.

II. Management Modes

It was hard to design this project as usual due to the scarcity of materials, equipment and personnel resulted from the lockdown of cities and Chinese Spring Festival holiday. The Leishenshan Hospital Project, which was critical to the fight against COVID-19, was completed as being monitored by more than 40 million "cloud supervisors" nationwide. In the construction process, design changes were made after discussions with the client, contractor, key subcontractor, and other parties concerned via onsite and video conferences, on the premise of not affecting the schedule. Meanwhile, CSADI also properly sequenced the critical construction procedures, paid attention to the transition among them, and reserved the required interval time through cooperation with the contractor, guaranteeing the design quality and satisfying the client's requirements. Finally, through **three adjustments in scale**, the Leishenshan Hospital, covered 79,900 m² and **completed within ten days**, become the largest new emergency hospital for infectious disease worldwide.

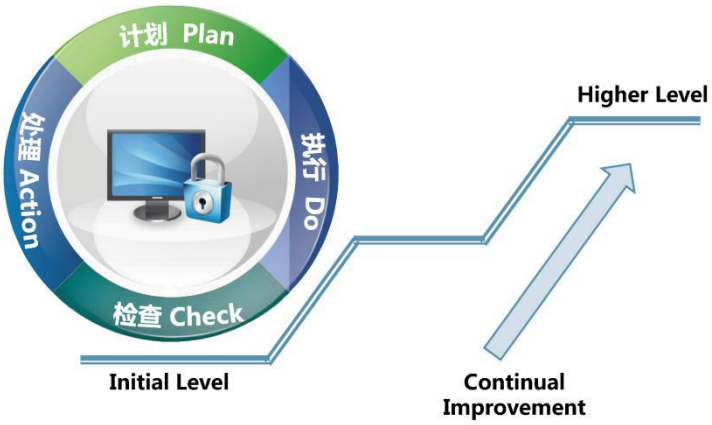
An emergency hospital for infectious disease involves numerous equipment pipelines, complicated technologies, and extremely high requirements on the prevention of nosocomial infection. Additionally, the structural, fire-fighting and biological safety must be guaranteed following the "**safe and quick**" principle, as a very small omission may cause medical or engineering accidents. **Hence, designers from all disciplines were extremely prudent during the design, inviting the chief architects and engineers to attend the project review in case of critical difficulties and work out technical proposals through discussions, in a bid to eliminate technical obstacles.** They also actively applied the fruits from the cooperative research with universities or colleges and enterprises to the design, ensuring the feasibility.



△ IPD Mode

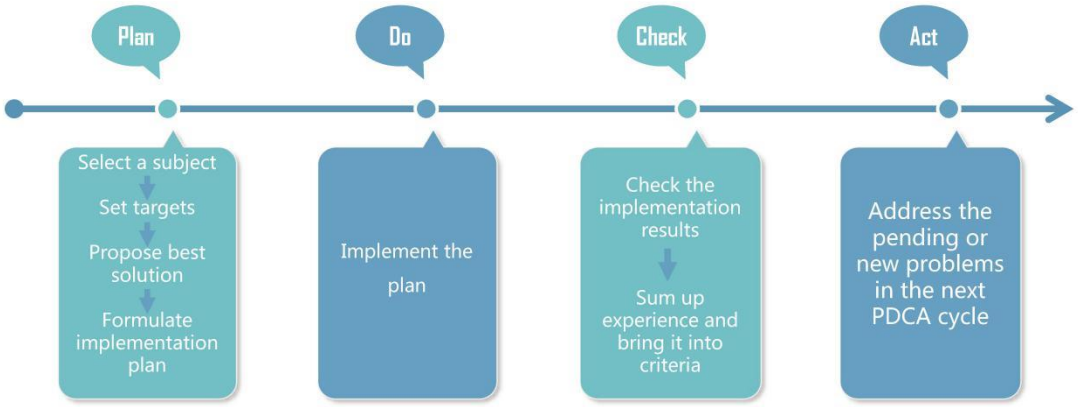
Even as construction conditions could not be fully guaranteed, CSADI's technical team prioritized the target that the construction should be as fast as possible to allow that each and every patient can be treated promptly.. To realize this, **the team applied the IPD mode to the design**, i.e. requesting the core participants to join in the design at early stage for jointly working out solutions and verifying the project targets. It made full use of the expertise of designers to assist the owner, construction agent, design institute, contractor, purchaser, supervision company, operator, property management company, and other parties concerned in developing the construction standard for emergency projects, establishing the construction targets, and overcoming related challenges. **Specifically, they effectively coordinated and completed the construction of over twenty works, including municipal, building, structural, water supply and drainage, HVAC, EE, construction cost, landscape, decoration, detailed design of steel structure, fire-fighting, intellectualization, medical technology, medical gas, sewage purification, and waste incineration.**

At the construction site of the Leishenshan Hospital, tens of construction procedures were conducted simultaneously and operators of different types of work and disciplines operated on the same working face. In peak hours, tens of thousands of people and several thousands of machinery were working on the site, making construction participants much pressured and anxious about the construction progress. **To realize efficient management, the Department Specialized in Healthcare Related Projects of CSADI drew the management experience from EPC projects. At that time, CSADI's staff worked in both offices and the construction site and conducted revisions of design and construction at the same time. The technical team even set up a 24-hour shift system to offer design and onsite services.** The Department Specialized in Healthcare Related Projects not only urged the design team to submit the drawings sooner, but also instructed the contractor to prepare constructors and materials in advance and helped set construction sequences on crowded working surfaces. Once the project moved into the stage of equipment installation, CSADI quickly responded to the owner's requirements by selecting professional construction parties specialized in Imaging and Laboratory, operation theatre and purification from its strategic partner bank.



△ PDCA Cycle Management

The **PDCA cycle management** was applied to each procedure to solve varied difficulties. CSADI was resolute in tackling each specific problem, in a bid to accomplish the project in the end. For instance, the selection of the hospital's roof involved four stages: The roof in the first draft of drawing was designed as steel structure pitched roof (**Plan**); then, the roof was changed to flat roof of container structure with reinforced waterproofing treatment due to tight construction period and purchasing difficulty (**Do**); next, the roof was again subject to further reinforced waterproofing treatment after the water test and actual rainstorm test (**Check**); finally, the steel structure pitched roof was added above the flat roof through the discussion with the owner (**Act**), thus ensuring the waterproofing effect. **Through the standardized cycle management, each problem was thoroughly resolved, so that the whole project was completed in a high-quality and efficient manner.**



△ PDCA Cycle Management

III. Technological Innovation

In response to the extremely tight design and construction period, CSADI always bore the previous lessons in mind and mainly made technological innovations on these four aspects when designing epidemic response projects.

First, prefabricated building: In the planning layout, several standardized and modularized basic functional units were adopted to realize volume production, high quality, quick installation and operation, thus conforming to the national initiative of green and energy saving, and environmental protection;

Second, cooperation with the team led by Prof. Lu Xinzheng from Tsinghua University: They simulated the relative concentration fields of harmful gases at different heights of air outlets outside the hospital to prevent cross infection caused by exhaust emission;

Third, cooperation with the team led by Prof. Lin Borong from Tsinghua University: They used the "high-precision online indoor environment monitoring and pre-warning system" developed by this team for monitoring the environmental safety in key diagnosis and treatment areas, and attained some results in the monitoring and pre-warning of the environmental safety of hospital;

Fourth, pioneering researches between CSADI and renowned scientific research institutions such as Dassault Systèmes SE: When designing the ventilation system for negative pressure wards of the Leishenshan Hospital, they jointly conducted simulation analysis on the airflow and contaminant dispersion in wards with **XFlow software**, and analyzed the relation between contaminant concentration and airflow at different positions of patients and medical staff, thereby providing technical basis for the design of negative pressure wards and effectively avoid the cross infection resulted from air flow and contaminant dispersion.

In addition, the design team harnessed smart remote technologies and BIM technology to realize visualization and analog simulation, which enabled it to guide the site construction and solve the problems encountered by construction participants via discussion. This truly embodied the lean construction and enhanced the construction quality of the Leishenshan Hospital Project.

Meanwhile, CSADI, busy with design and construction cooperation, also assisted the Department of Housing and Urban-Rural Development of Hubei Province in inviting experts to summarize their experience in fighting against COVID-19and jointly compile the ***Design Guideline for Temporary Hospital for Respiratory Infectious Disease (Trial)***, ***Technical Guideline for Design of Makeshift Hospital (Bilingual Version)***, **and** ***Technical Guideline for Design of Temporary Isolation Sites*** **in a short time, which effectively supported similar project construction in Hubei Province and other areas of China.**

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Concluding Remarks

After being put into use, the epidemic response projects in Wuhan greatly alleviated the problems in obtaining professional diagnosis troubled COVID-19 patients here, won acclamation from all parties, and played a decisive role in combating the epidemic in China. Over thirty years ago, CSADI and China Construction Third Engineering Bureau Co., Ltd. jointly built the International Foreign Trade Center in Shenzhen — the earliest skyscraper in China. With one storey completed in just three days, they created the "**Shenzhen Speed**". In 2020, the two companies again created the "**Wuhan Speed**" by completing the Leishenshan Hospital with 1,500 beds in just 10-odd days. **Based on these design and construction practices, some lessons and experience were summarized as below.**

1. Proper and scientific project site;

2. Convenient transportation and public facilities;

3. Standardized and modularized design and structure;

4. Reserving enough installation space for equipment load and E&M pipelines;

5. The integration level of fabricated building is to be improved;

6. It is recommended that the "design of emergency hospital" be included into the industrial standards and specifications, so that quick construction could be realized while ensuring the basic functions.

We write down the experience obtained during the design and management of the Leishenshan Hospital Project, looking forward to helping other countries and regions fight against COVID-19. We hope the people worldwide **go hand in hand in combating the epidemic inspired by the "Leishenshan Spirit" and jointly build the community with a shared future for all mankind.**

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