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# IMPROVEMENT OF VERNACULAR HOUSING FOR DISASTER PRONE AREAS IN BANGLADESH: A SIX YEAR EXPERIENCE

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## ABSTRACT:

In 2007, a super cyclone Sidr devastated one-third of Bangladesh. Caritas CRAterre and BUET were involved to collaborate on the development of disaster resilient houses. Although more than 80% population lives in non-engineered houses, there are few researches in this field. To address this situation, BUET engage on a pilot project in 2009, in two different regions. A meticulous local survey was carried out, focusing in the building culture, its strength and weaknesses. Based on available material testing, and a 3D stress analysis of the structure, and including cultural, social, environmental and economical aspects, initial design was developed. After two levels of validation by beneficiaries, 25 houses were built on the affected areas. Based upon this experience, a 3 year subsequent project, covering the whole country, started in 2011. Intervention is developed through a strong participatory approach, and a deep understanding of local existing context. This paper presents the results and outcomes of the on-going project.

## 1 INTRODUCTION

Bangladesh is known as one of the most disaster prone countries in the world, due to its geographic location and socio-economic condition of people. About 50% of the land is within 6–7 m from Mean Sea Level (DMB, 2008). Common disasters of Bangladesh are flood, cyclone, tidal surge, land slide, river bank erosion, draught and earthquakes. Lots of houses are damaged due to disasters on a regular basis, which caused the most economic losses during disasters (DMB, 2008). In recent years, these have caused extra burden for the marginal people of the country, jeopardizing its economic growth as a whole. Although it is a small country, its culture, disasters, and availability of building materials are diverse, and the housing practices are also widely varied.

Government and NGOs provide housing to the disaster affected people. Some are very costly and strong enough and some are very nominal and temporary. However, constructions of these houses generally do not respect local culture and sometimes

are constructed in highly vulnerable locations. After the construction of houses led by an external agency, it is rare that the community replicates the same design. In 2007, a super cyclone, Sidr (wind velocity: 242 km/hr; tidal surge height: 5 m), passed through Bangladesh and damaged lots of houses. In response to that cyclone, many houses were constructed by government and several NGO. However, many of them were constructed in vulnerable locations, as usual.

Different international guidelines are available for a number of years. At the same time, there is a lot to learn from the existing vernacular houses, even if they lack technical adequacy. A question may naturally be asked: why are these not being followed in practice? The answer is that R&D does not focus enough on local practice; does not take into account local technical and financial capacities, and that the fruits of existing R&D are not being transferred into the field, as these houses are mostly designed and built by owners or artisans, who do not have access to those booklets. Current codes do not have also provisions for disaster resistant rural house design and so, there is no policy related to rural housing improvement that may reduce risk and improve disaster preparedness strategy in this particular sector.

There is a gap among the responding agencies for not having an effective design and technology for the construction of Low Cost Houses (LCH). When implementing a post disaster program, most of the time, the focus is on providing approaches for giving a shelter, than in enabling strategies to help people to access knowledge, which will help them to build on their own and more resilient houses. This is important to take into account, as each community has its own construction techniques and materials for LCH. Some of them are very effective and scientific. These are sometimes overlooked and so, there is a gap in understanding the local knowledge for having effective design and technology for the construction of LCH. Obviously, there is a necessity for bridging this gap, by learning from the people and then, transferring the improvement back to them, through disseminating this know-how to responding agencies. There is no doubt that input of local people, local artisans, and strong understanding of local culture and general context should be considered for sustainability. To this context, at a first phase, a one year project (2009) has been completed in Bangladesh. Upon its successful completion, an extended three years (2010–2014) project is being undertaken.

## **2 BACKGROUND AND OBJECTIVE OF THE PROJECT**

Caritas Bangladesh (CB), as a human development organization, has been constructing shelters, i.e., LCH for disaster-affected families since 1970. From the long experiences, CB came to assess that each type of context (including hazards) is different, and the people have cultural distinctions. Moreover, the natural resources are different from one site to other. Therefore, the strategies for shelter are also not the same. But, previously one particular model house design was prepared by CB for all areas of Bangladesh. Some modifications were done from time to time, considering disaster, geographical area; and cultural aspects were also considered in some cases. Community people's opinions were sometimes taken into considerations for the design of houses. But these were not adequate as a proper and systematic methodology, and were not implemented. Similarly Caritas Bangladesh constructed LCHs in Sidr 2007 affected areas, having financial support from Secours Catholique/Caritas France. An

evaluation was carried out in 2008 by the International Centre for Earth Construction (CRAterre-ENSAG) for Caritas France supported houses. In the evaluation report, it was recommended that local context should be more importantly taken into account, to help such program to achieve a better impact in local houses resilience. To this context, CRAterre suggested CB to approach BUET, to provide technical assistance towards their LCH Project in disaster-prone areas. CRAterre, as a consultant to Caritas France, also joined to provide technical and methodological support. With financial support from Caritas France, one pilot-project was implemented in 2009–2010 to apply the suggested new approach. Two contexts were studied: one in a cyclone prone area, and the other in a flood prone area. This project showed that it is feasible to develop contextual solutions that fit better to people needs, and that have better impact, both in the local economy, and the local building practices.

Upon successful completion of first phase, CB took up its second phase (October 2011-September 2014) for other six regions of Bangladesh, with funding support of Caritas France and Caritas Luxembourg, where CRAterre-ENSAG and BUET were the technical partners of the project. Findings from the first phase have been considered for the project extension. The main objective is to develop adequate methodological approach, in order to minimize the impact of recurrent disasters on LCH, and to ensure that people of disaster affected households live in disaster risk resilient houses. In the project, 30 types of LCH are being designed, for 30 disaster prone areas. The idea is to work on housing improvement, future risk reduction, and disaster preparedness by developing LCH to be implemented after disaster. Figure 1 shows the conceptual approach of LCH project. Finally, the learning will be disseminated to the rural people, engineers, other NGOs and educators. This paper presents the findings of the completed first phase of the project and presents also briefly the salient features of some regions of the on-going phase.

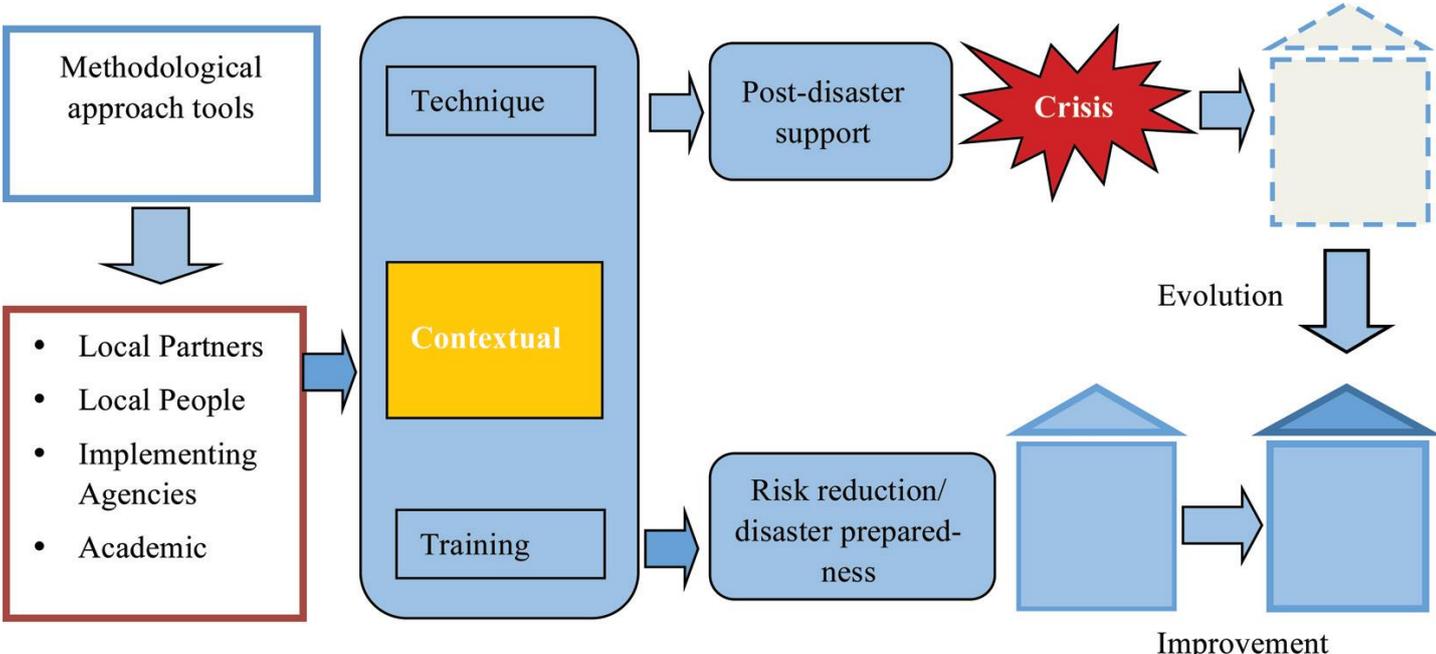


Figure 1 The conceptual approach of LCH project (Credits: Caimi and Moles, 2012).

### **3 PROJECT LOCATIONS**

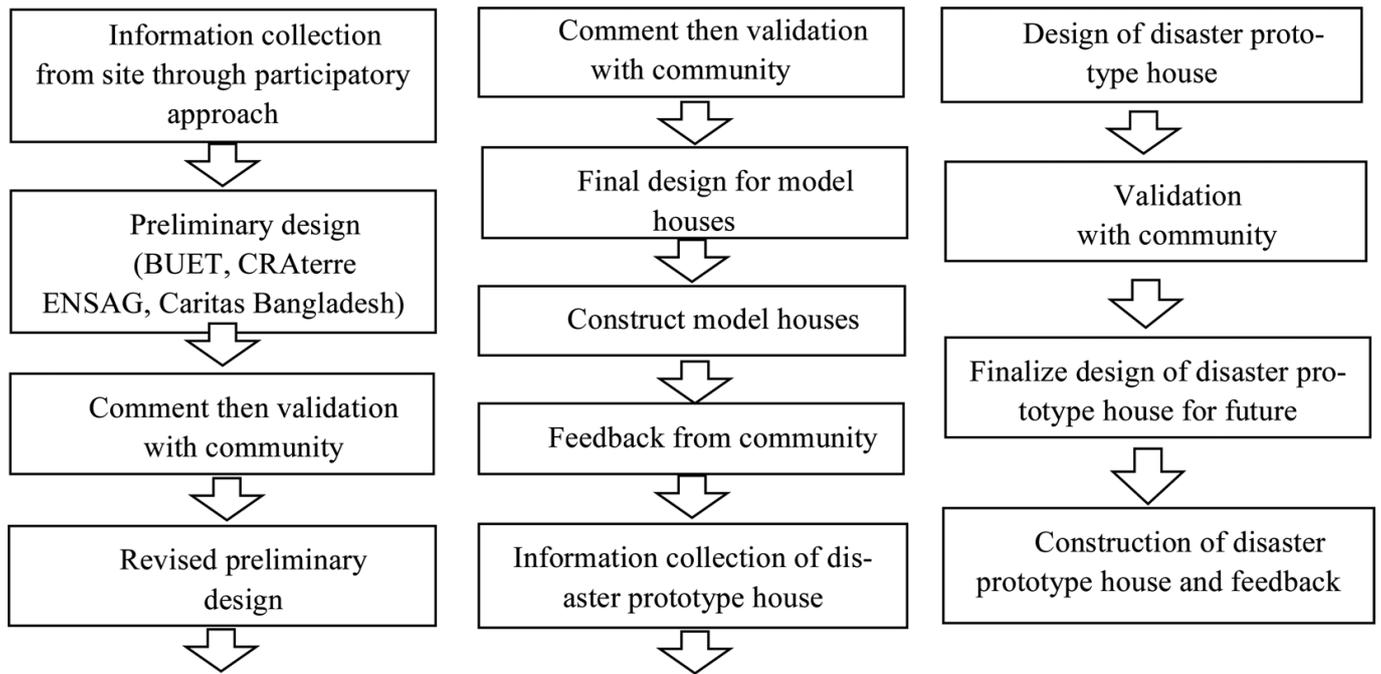
At the first phase of the project one area was selected in the cyclone prone region (Kuakata of Patuakhali district), and another area was selected in the flood prone region (Sirajdikhan of Munshiganj district). At the second phase, the project areas were selected in Bandarban (flash flood, cold wave, landslide and fire), Asasuni (cyclone), Kanighat (flood zone), Dhubaura (flash flood), Gaibandha (river bank erosion) and Porsha (drought and cold wave).

### **4 DESIGN STRATEGIES AND PROJECT SEQUENCE**

Project sequence has been presented in Figure 2. Three-stage community level meetings were held to collect local information and views of the people, along with the artisans. Properties of the local construction materials were ascertained from laboratory tests. Considering the service and environmental loads, designs were finalized based on Finite Element Modeling (FEM). Model houses were constructed at the selected locations to demonstrate them to the local community, aiming to the new design, or at least some features would be replicated. Performances of these model houses are being monitored. The main aspects of development of disaster resistant housing consists of (i) survey, (ii) design, construction and technical improvement, (iii) dissemination of learning, (iv) follow up and monitoring.

As shown in Figure 2, at first, information was collected from the site, using a questionnaire survey. A detailed questionnaire has been developed to collect social, economic, and technical related information. Based on the collected data, a preliminary design for better resilient houses was conducted by BUET, CRAterre and CB. This design was validated by the community people, including local allies and artisans, and the design was revised, considering those feedbacks. Again, the revised design was validated by the community. Thus, the final model design for any particular context was developed. Based on this models, houses were constructed in project areas. Feedbacks of the community were taken again on the model house. Adjusting the applicable comments the design was improved and another house was constructed.

Based on the experience of survey, two types of design have been developed. The design and construction of LCH prototypes were prepared to be implemented at rapid response, just after the disaster and it improved the design for normal time construction. LCH prototypes, as well as solutions for housing improvements, are also demonstrated for training local artisans; sensitize populations and getting feedback from the local people.



**Figure 2** Sequence followed for developing the design of LCH in the project. (Credits: O. Moles et al.).

#### 4.1 Survey

Following are the key features of the survey:

- Inform local people about the LCH programme;
- Rapport building, based on meeting with local authorities, community leaders, etc.;
- Development of survey formats for obtaining the social and technical information;
- Survey on the types of existing houses, size, material costs and social map;
- Community meeting to understand the social and economic conditions, including housing;
- Transect walk/observation and selection of houses to be assessed;
- Individual house assessment (technical detail);
- Meeting with artisans and people involved in the construction to understand types of houses and availability of artisans, materials, rates etc.;
- Analysis of the survey to determine the design strategy for different types of LCH.

#### 4.2 Design steps

Main steps in the design followed:

- Preparation of preliminary design, based on a primary survey (BUET);
- Sharing among CB, BUET and CRAterre for feedbacks;
- Preparation of the draft design (BUET);
- Selection of treatment method for different elements of the structure (CB, BUET, CRAterre);
- Cost estimation (CB);
- Sharing the design with the community for their inputs (CB and BUET);
- Incorporate feedbacks and validation with community;

- Preparation of the final design (BUET).

#### 4.3 Construction of houses/shelter

Main steps in the design followed:

- Formation of Project Committee (PC);
- Community-led beneficiaries selection (CB);
- Training of artisans (CB and PC);
- Selection of artisans (CB and PC);
- Procurement of materials (CB and PC);
- Treatment of materials (CB, artisans and PC);
- Organization of the house, position and space arrangement (CB, beneficiary, artisans and PC);
- Construction of 2 houses, one for each model (CB, PC, artisans and community);
- Providing feedbacks for improvements (CB and BUET);
- Validation of 2 houses for improvements (CB, BUET, PC, artisans, community and beneficiaries);
- Construction of the rest 2 houses (CB, PC, artisans and community);
- Improvement/ repair of houses;
- Construction of 6 disaster prototype houses in 3 disaster risk areas;

#### 4.4 Monitoring/follow up phase

Performance of constructed houses is being monitored in the following way:

- During construction (CB and BUET);
- After construction: every 6 months (CB).

### 5 DESIGN OF LCHS

Proposed LCH design should respect local practice and culture. Information is collected to identify the client/beneficiary needs. Also the local masons, and carpenters availability are given consideration. Meanwhile, it is also particularly important to be accountable from what is delivered to local population. For this reason, it was crucial to be able to scientifically assess the behavior of the various concept developed within the whole project.

#### 5.1 Design in cyclone-prone area

##### 5.1.1 Design considerations

A four pitched roof is selected for better wind resistance in the cyclone-prone area. As per BNBC 1993, the house should be designed for 260 km/h fastest mile. However, as these houses are not alternative to cyclone shelter, a realistic compromise on wind speed had been reached. Since these houses are vernacular in nature, and cannot be treated as an engineered one, these buildings cannot satisfy the building code requirements. A RC and timber framing system, which is common in the area, is chosen. For the post, 1:2:4 concrete reinforced with mild steel bars is selected, whereas timber from locally available rain tree is used for beams and roof rafters. Timber

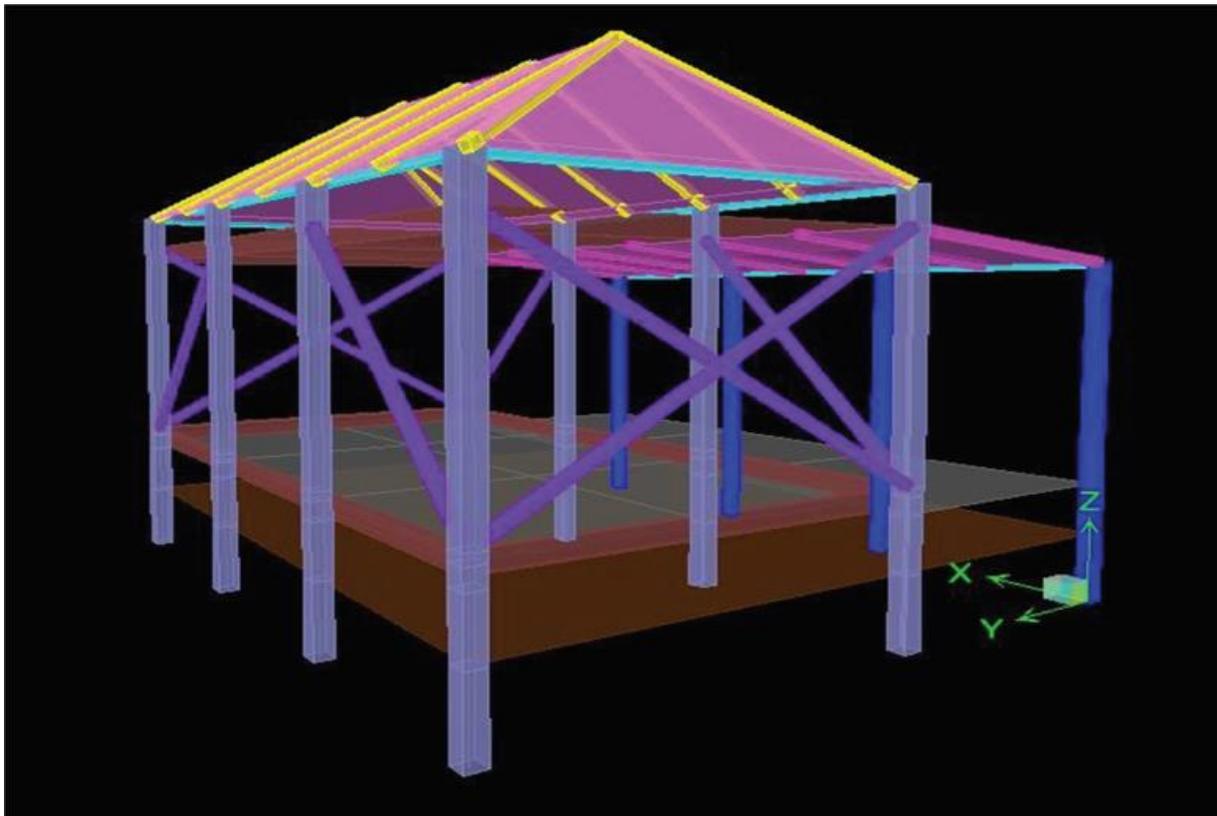
properties have been ascertained from laboratory testing. A stepped earth plinth is chosen for better protection, as the local soils are silty sand. Two parts of bamboo fences were used for better maintenance/ repair of the lower part fence.

### 5.1.2 Material testing

Collected soil samples, local building materials (wood, water) were tested at the BUET laboratory.

### 5.1.3 Finite element analysis

Based on the considerations, a 3-D finite element analysis was carried out (Fig. 3). The photograph of the Figure 5 shows the constructed house. FE analyses show that diagonal bracing would be better resistant to wind. However, finally due to construction difficulty, the diagonal bracings were changed to corner bracing.



**Figure 3 3-D finite element model of the proposed house in Kuakata. (Credits: O. Moles et al.).**

## 5.2 Design in flood prone area and on river bank

### 5.2.1 Design considerations

A two pitched roof is selected for flood-prone area. As per BNBC 1993, the house should be designed for 210 km/h fastest mile. However, a realistic compromise on wind speed had been reached. A RC and timber framing system, which is common in the area, is chosen. For the post, 1:2:4 concrete reinforced with mild steel bars is selected, whereas timber from locally available rain tree or Mehagani is used for beams and roof rafters. Timber properties have been ascertained from testing. A stepped high earth plinth is chosen for better protection, as the area is flood prone. Two parts of the bamboo fences are considered for better maintenance of the lower part fence. A loft is provided to save valuables during flood.

### 5.2.2 Finite element analysis

Based on the design considerations, a 3-D finite element analysis was conducted. Although in the regions near or on the bank of the river, flooding is a common problem, river bank erosion causes shifting of houses. Main design considerations were to construct a house, which can be dismantled within a short notice (based on local practice identified during the assessment of local practice). Also different types of 'katla' (which provides joint between the post and foundation) have been used to see their performances. Stepped footing, and three part fencing have been used in the design for better protection against rain-cut erosion. Figure 5 shows a completed house in the Gaibandha region.



Figure 4 Photograph of a completed house in Kuakata. (Credits: O. Moles et al.).



Figure 5 Photograph of a completed Machan House. (Credits: O. Moles et al.).

### 5.3 Design in hilly region

For the hilly region of Bandarban, in order to address cultural specificities of communities living together in existing villages, two types of houses were designed i.e., 'Machan House' (house on platform) and 'House on Ground'. Machan Houses are a traditional practice of the region, whereas Houses on Ground are another alternative, due to cultural diversity. The Machan design has followed the traditional shape of original inhabitant, while the house on ground is the type used by new communities. A constructed Machan house is presented in Fig. 5. Some improvements have been tried:

- Lesser number of bottom posts has been found to be adequate for machan house;
- Corner bracings have been added to improve wind resistance;
- Different treatment plan for bamboo and wood have been employed and being monitored;
- Different 'katla' arrangements have been tried.

## 6 FUTURE PLAN

In this project LCH prototype has been developed for all the selected areas. It is also determined which improvement to be done on existing housing and local practice, in order to make these houses more resilient to local hazards. CB identified that medium income people are changing their housing practices, and sometimes resulted in more vulnerable houses. For example, in Shylet, due to recurrent floods, local people are shifting from earthen architecture to fired brick houses. Due to the lack in the financial capacities, local peoples are motivated to construct 50 mm thick, fired brick walled houses. This type of houses might be resistant to flood, but vulnerable to earthquakes.

Another challenge for the next project step is to try to access the closest resources (materials, labors, management etc.) for implementing post disaster response, or housing improvement projects.

## 7 CONCLUSIONS

About 60% of the families in Bangladesh live in vernacular houses. This sort of infrastructure is easily damaged by natural disasters, such as floods and cyclones. So, preparation for appropriate design and structure of LCH is a crying need. The main aspects of the research project are as follows:

1. In designing houses the level of hazard needs to be estimated. It is important to use locally available materials and technology, and to show respect for local culture and practice. Even in the same area, house design varies significantly. Importance must be attached to the affordability, safety and re-applicability of the community.
2. Model houses are designed and constructed in four disaster prone areas of Bangladesh, based on community participation. For designing the houses, local materials were chosen and the skill of local mason and carpenters were kept in mind.

3. The completed houses performed well, and these are well accepted by the local community. However, performances of the constructed houses are being monitored.
4. Caritas staff members should incorporate their knowledge and skills in disaster preparedness and emergency response activities. CB may propagate the acquired knowledge learning to national and international NGOs, government sectors and Caritas International partners.
5. Educational institutes like BUET and practicing engineers can incorporate the learning from the project into the building code, text book etc. Expansion of research regarding LCH and related topics will have to be included in the curriculum of the technical institutes and universities without delay.

## **ACKNOWLEDGEMENTS**

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