第7章　広報活動の概要

7.1　技術基準についてのワークショップ及びブロック積デモンストレーションの開催

2023 年度においては、主要な活動として、設計実務において本ガイドラインの適用が実現するよう、設計等に携わる技術者を主な対象とする広報のためのワークショップを、フィリピン国内 3 か所程度（マニラ首都圏、中部ビサヤ地域、南部ミンダナオ地域を想定）において、フィリピン構造技術者協会（ASEP）と北海道建築技術協会（HoBEA）との共催により開催した。併せて、ブロック積み施工のデモンストレーションをメトロマニラ近郊のブラカン州において開催した（詳細は、第4章　フィリピン現地ワークショップ及びブロック積み施工デモンストレーションの開催並びに関連調査を参照）。

開催の概要は、以下のとおり。

(1)技術基準についてのワークショップ

フィリピン構造技術者協会との共催により、下記の 3 か所において、同内容により開催した。この 3 か所で開催する方式は、同協会が会員などを対象とする種々の広報活動の場合に通常採用する方式であり、それぞれの地域の同協会の会員の協力により実施される。今回も、それぞれの地域の会員の協力により開催され、司会はそれぞれの地域の会員により行われた。なお、参加受付などをするために、本部事務局より 2 名が同行し、開催準備、会場設営、開催時の参加者の受付、CPD 認証のための受講証明書の配布などの事務施工を実施した。

次第は下記のとおりで、3 か所同一の内容である。講演は、できる限り、今後、継続的に広報活動を担っていくことが期待されるフィリピン構造技術者協会に行ってもらうこととした。（例えば、設計事例は、本プロジェクト 2022 年度活動において西川忠委員の作成）

－両国の国家斉唱
－主催 2 団体の開催挨拶
－これまでの経緯と日本の CHB の概要：HoBEA　檜府
－フィリピンにおける CHB の実態とこれまでの地震被害：ASEP　Juanito Cunanan（組積造担当）
－日本の経験に基づく壁式 RCHB と非構造壁のガイドラインの背景：HoBEA　石山
－壁式 RCHB の設計・施工のガイドライン：ASEP　Ronaldo Ison(マニラ。前会長)／ Mark Elson Lucio（ダバオ及びセブ。会長）
－RCHB ガイドラインによる設計事例：ASEP Ariel Santos（前会長）
－パネルディスカッション
－閉会挨拶：ASEP（各地域の代表者）
＊進行：各地域の会員

① 2024 年 1 月 18 日1－5PM　メトロマニラ・ワークショップ
　会場：ケソン市 Luxent Hotel

参加者:107 名(申込者リスト登録者数)

オンライン中継実施(日本などから聴講)

② 2024 年 1 月 23 日1－5PM ダバオ市ワークショップ

会場:Rogen Inn

参加者:86 名(申込者リスト登録者数)

③ 2024 年 1 月 24 日1－5PM セブ ワークショップ

会場: Bai Hotel Cebu

参加者:参加者 106 名(申込者リスト登録者数)

(2)ブロック積み施工デモンストレーション

本プロジェクトにオブザーバー参加いただいている、株式会社ねこ社に委託し、同社関連会社の敷地、ブロック積み職人により実施した。なお、会場はマニラ首都圏から車で 1.5 時間ほどかかるため、マニラ市公共事業道路省本省と会場とを往復するバスを主催者側で用意した。

日時:2024 年 1 月 19 日10－12AM

会場:ブラカン州栄住ビルディング

参加者:約 50 名(マニラ市より送迎のバスを用意)

(楢府龍雄)

7．2 第 18 回世界地震工学会議への投稿

(1)背景

フィリピンと同様に、低品質のコンクリートブロックと施工レベルが課題となっている国は多い [1)]。また、焼成煉瓦が多用されている国で、零細メーカーによる製造に伴う、大気汚染、エネルギー浪費、農業用地の荒廃などが深刻な課題となっており、代替の材料としてコンクリートブロックの開発に取り組んでいる国も多い [2)]。こうした国々にとって、本プロジェクトの取り組みは参考となると考えられる。

このため、本プロジェクトの概要を広く国際的に情報発信するため、4 年毎に開催される地震防災分野の大規模国際会議である世界地震工学会議に、フィリピン側参加者を含めた参加者の共著により、論文投稿を行った。

(2)投稿の概要

投稿の概要は以下のとおり。

・会議名称:第 18 回世界地震工学会議(18WCEE、 18^{th} World Conference on Earthquake Engineering) https://www.wcee2024.it/

・会議日程:2024 年 6 月 30 日—7 月 5 日

・会場:イタリア　ミラノ

・投稿スケジュール

-アブストラクト締め切り:2023 年 5 月 31 日

-投稿締め切り:2023 年 10 月 31 日、その後、セッション議長による査読

-査読結果に基づく改訂投稿の締め切り(改訂投稿:別添のとおり):2024 年 1 月 31 日

・投稿のタイトル;DEVELOPMENT OF GUIDELINES ON REINFORCED CONCRETE HOLLOW BLOCK (RCHB) CONSTRUCTION IN THE PHILIPPINES

・著者:T. Narafu, Y. Ishiyama, R. Ison, A. Santo, J. Cunanan, T. Uematsu,
T. Nishikawa, H. Imai, S. Matsuzaki, K. Shirakawa, A. Maeshima, T. Yoshino

・投稿区分(セッション):CMS-5 Seismic design of modern masonry: Innovative systems, experimental experiences and codified criteria

1)　本プロジェクトの下記の報告書を参照。

・2021 年度報告書　第6章 コンクリートブロック造の課題と期待の国際的な広がり
6.1 低品質のコンクリートブロック造の課題の地域的な広がり

・2022 年度報告書　第7章　関連して実施した活動
7.3　低品質のコンクリートブロック造の課題の広がり

2)本プロジェクトの下記の報告書を参照。

・2021 年度報告書　第6章 コンクリートブロック造の課題と期待の国際的な広がり
6.3 地球環境問題の観点からの期待

(楢府龍雄)

18TH WORLD CONFERENCE ON EARTHQUAKE ENGINEERING
WCEE2024
MILAN

MILAN, ITALY
30TH JUNE - 5TH JULY 2024
www.wcee2024.it

DEVELOPMENT OF GUIDELINES ON REINFORCED CONCRETE HOLLOW BLOCK (RCHB) CONSTRUCTION IN THE PHILIPPINES

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Abstract: *In the Philippines, concrete hollow block (CHB) is widely used in construction (bricks are used quite rare). Low-rise houses of low-income groups with little intervention of engineers are constructed with CHB. Most of CHB are manufactured by small-scale industry without quality control and extremely vulnerable. Construction work is usually done by non/semi-skilled workers. Many non-structural walls within reinforced concrete (RC) structures are constructed in similar way and suffer serious damage from earthquakes. The original technology on CHB created in the United States is a technology developed by engineers. Japan introduced the technology as a fire-resistant structure with affordable cost just after the World War II for reconstruction from devastation. At the beginning, most of manufacturers of CHB in Japan were small scale with little engineering knowledge similar to the Philippines. Then the central and local governments and other relevant organizations tried to improve the situation by working on manufactures, workers and so on. They encourage every stakeholder in construction sector to apply this technology. Those constructions have been showing very good performance against fires, and also, other disasters such as earthquakes and tsunamis. Under this situation the Hokkaido Building Engineering Association (HoBEA) in Japan and the Association of Structural Engineers of the Philippines (ASEP) agreed to collaborate to create new guidelines on reinforced concrete hollow block structures for low-rise buildings (bearing wall type) and non-structural walls. The draft of the two guidelines have been elaborated and ASEP Board meeting approved them. Now they are under preparation for submission to the relevant central government to be designated as a referral code in building regulation. Both guidelines are characterized as below. - Safer by using high quality and well-shaped CHB (price of CHB unit: 1.7-2.0 times more expensive), - Cost effective by saving mortar in spite of high price CHB (total construction cost for wall will be less by 5-10% than the conventional way, by a) only hollows with reinforcement are grouted, b) thinner bond mortar with well-shaped CHB, and c) thinner surface plastering), - Effective block laying applying stack bond instead of running bond, - Simpler construction with less RC members and simple-shaped beams. Those guidelines are expected to be applied in other countries in the following situations. - CHB structures are poor quality and not safe, - Low quality burnt brick is widely used which causes serious problems such as air pollution, inefficient energy consumption, and so on, - Non reinforce masonry walls (brick or others) often suffers damage from earthquakes. CHB could be a possible good alternative to burned brick.*

1. Background

1.1 Vulnerability of concrete hollow block construction in the Philippines

In the Philippines, concrete hollow block (CHB) is widely used in construction, whereas bricks are used quite rare. Houses of low/middle-income groups constructed by local workers are constructed with CHB (Figure 1). In addition, many non-structural walls (outer/cladding walls, partition walls, and so on) in engineered buildings (designed and supervised by engineers) such as reinforced concrete (RC) structures are also constructed with CHB (Figure 2).

Most of CHB are manufactured by small-scale industry without quality control required by the Philippine National Standards (PNS) and extremely vulnerable (Figure 3). Most of them would break if those fall to ground from hands of workers. Further, dimension and shape are not precise. Those are vulnerable and often get broken, and broken ones are also used. Those conditions require thick bonding mortar, thick plastering mortar and large amount to fill the voids of broken parts when laying blocks. Construction work is usually done by non/semi-skilled workers and wall surfaces are rough and not orderly (Figure 4). Those constructions are very vulnerable and suffer heavy damage by earthquakes again and again (Figure 5, 6).

Figure 1 CHB houses in the Philippines. Left: residential area of low/middle income people in Payatas, Metro Manila, Right: construction for middle income people by a developer, Metro Manila

Figure 2 High-rise building under construction in Metro Manila. Left: view of the total structure, Right: detail of the buildings. CHB is used for outer walls.

Figure 3 A small scale manufacturer of CHB. Left: simple manual manufacturing machine, Right: curing field for CHB in open air

Figure 4 Construction site by a developer. Left: construction work of CHB wall with pipe for electric cable, Right: Appearance becomes pretty good after finishing work

Figure 5 heavily damaged houses by the Bohol earthquake 2013


Figure 6 Heavily damaged building by the Bohol earthquake 2013. Left: view of total building of municipal government office of Sagbayan, the Philippines, Right: Close-up view of the building in the left. Outer non-structural CHB walls were completely destroyed.

1.2 Overview of concrete hollow block technologies in Japan

The CHB technology was introduced in Japan during the period for reconstruction from the devastation by bombing during the World War II. Since Japanese cities suffered very serious damage by fire during the World War II and the Great Kanto Earthquake in 1923, fire resistant construction technologies with affordable cost were very keen issue at those times. Therefore, the Japanese government introduced the technology from the United States and encourage stakeholders in building and housing sector to apply it. Many houses and building are constructed including governmental rental housing during the period and still in use in good condition (Figure 7). Those buildings have shown very good performance against fires and, also against earthquakes and tsunami (Figure 8).

Figure 7 Rental CHB houses by municipal government of Eniwa City, Hokkaido. Still in use after about 50 years since construction.

Figure 8 Totally inundated house by the Great East Japan Earthquake and Tsunami 2011. The tsunami height was higher than the roof judging from debris on the roof. CHB wall structure got almost no damage. (Source: Hiroko Minoda and Yasumichi Mifune)

1.3 Collaboration project between the Philippines and Japan

Under the situation in the Philippines mentioned above, the Hokkaido Building Engineering Association (HoBEA) *[1]started a project to disseminate the reinforced concrete hollow block (RCHB) technology developed in Japan with support of Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) in 2018.

2. Outline of the collaboration project

2.1 Preliminary surveys, discussions and other activities

Since 2018, HoBEA has been conducting various activities as follows.

1) Preliminary field survey

- survey on manufacturers of CHB in the Philippines

- field survey on practice of CHB constructions in the Philippines

- survey on structural codes and building regulatory scheme in the Philippines

- survey of possible users of the improved CHB technology (contractor, developers, NGOs, etc.)

2) Explanation of the technology such as in seminars, session in an international conference, and others

- seminars in Department of Public Works and High ways (DPWH), National Housing Authority (NHA), Philippine Chamber of Commerce and Industries (PCCI), and so on

- a session in an international conference organized by the ASEP

3) Discussion with relevant organizations

4) Technical visits to Japan by leading persons of the Philippines

2.2 Study on target buildings and possible approaches

Based on the activities described in the previous section, HoBEA grasped situations relating construction practice such as quality of CHB products, manufacturers, design, construction works, workers, and so on, as well as regulatory schemes such as building regulatory scheme, technical guidelines, products standards including responsible and relevant stakeholders involved in.

Considering all the issues, HoBEA selected two types of constructions below as target building types.

1) load bearing type of low-rise small buildings, and

2) non-structural walls installed in RC structures or others,

Then they identified possible approaches to disseminate the technology in the Philippines as below.

1) creation of a technical guideline which is utilized in building regulatory procedures.

2) creation of a new section on CHB construction in the technical guidelines and standard specifications for governmental buildings designed and supervised by DPWH

3) application for a technical approval scheme for socialized houses managed by NHA

4) collaboration with NGOs which supply houses in the Philippines

5) improvement of quality of CHB through implementation of product standard (responsible organization: Burau of Philippine Standards, Department of Trade and Industry (BPS/DTI)

6) training program to develop skills of CHB laying workers

7) awareness raising campaign for people involved in construction of buildings (customers/owners of buildings, developers, contractors, and so on)

2.3 Approach to create technical guidelines which is applied in building regulatory procedures

Among the several possible approaches stated above, HoBEA decided to choose the creation of technical guidelines which are applied in building regulatory procedures. The guideline on load bearing type for low-rise buildings is selected for the first step. The reasons of the choice of the approach are as follows,

1) Building regulation of a long history and its social acceptance in the Philippines

The Philippines has a long history of building regulation such as building permit and site inspections based on the National Building Code of the Philippines (NBCP. Presidential Decree No.1096,1977), which has been accepted by society. Several technical guidelines such as on structure, fire safety, and so on, are prepared and applied in the procedures. A new technical guideline created by this project is expected to be one of these technical guidelines.

2) Good relation among the key persons in ASEP and HoBEA and their positive stand on the proposal

The association of professionals, the Association of Structural Engineers of the Philippines (ASEP), creates national structural codes. The DPWH is the relevant governmental organizations for the building regulations. Some key persons of HoBEA have a good relation with those organizations through collaborative research activities and technical cooperation projects by Japanese Government. Further, both key organizations have positive stand on the proposal by HoBEA to create a new technical guideline to be used in the building regulation.

2.4 Framework of the procedures and target buildings

The building regulation in the Philippines has been implemented by local governments based on the NBCP. Several technical codes are prepared by organizations of professionals and the DPWH designates them as referral codes for building regulation. On structural fields, ASEP publishes the National Structural Code of the Philippines (NSCP. the first edition in 1972 and the latest one, the 7th Edition, in 2015). The NSCP refers to the codes of the United States and contains a chapter on masonry. However, it handles only engineered buildings designed by engineers based of structural calculation using various loads (on structural members). Therefore, NSCP mentions that on small houses (usually structural calculation with loads are not necessary), “referrals are made to NSCP Volume III on Housing”. However, NSCP Volume III has not published yet.

Under the situation, most of low-rise houses can be categorized in two kinds of 1) RC frame structure designed by engineers (infill walls by CHB), or 2) CHB houses by local workers not compliant to the code. The new RCHB guideline aims to be applied for both types as simple and practical guidelines just same way in Japan.

2.5 Procedures to create the technical guideline

For the first step, the guideline on bearing wall type for low-rise buildings is selected. Draft of the guideline is prepared based on the guideline of Japan with some modifications mainly for simple and practical construction work. To verify safety on modified part or others, several physical experiments were conducted (Figure 9). The draft is reviewed by experts of both sides from the view point of requirement on loads or others stipulated in the NSCP, standards on manufacturing of CHB (Philippine National Standards PNS), and social acceptance in the Philippines (applicability and acceptability by average construction workers, etc.).

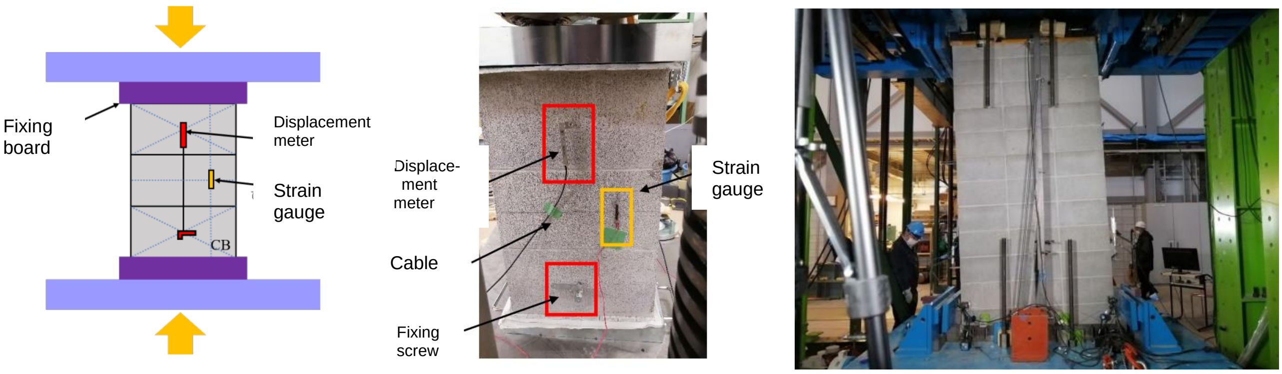

Figure 9 Examples of the physical experiments which HoBEA team conducted. Left: set up of compression test of prisms of CHB, Centre: attachment of gauges and meters to a prism, Right: set up of a specimen to evaluate effects of aspect ratio of CHB walls by lateral force

3. Outline of the technical guideline

3.1 Policy to create the guideline

Japan has a long history to develop and elaborate the CHB technology and realized a high level of safety. However, from the view point of simple and efficient construction work, current RCHB technology has several points to be improved. Considering this condition and further construction practice in the Philippines, a policy to customize the technology to be suitable to the Philippines is agreed by both sides. Cost is very important issue for acceptance by the people in the Philippines. Considering all these issues, the technical guideline has been discussed and finalized.

3.2 Outline and features of the guideline

3.2.1 Outline of the guideline*2

1) Applicable buildings: low rise buildings up to 3-story

2) Structural system: bearing wall structure (RC columns are not necessary)

horizontal structural members (cast in situ RC): slabs with built-in bond beam (no beam) or beams with simple shape and appearance (same width with walls below to eliminate beams bulging out) and for easy construction work (simple form work for concrete casting) (Figure 10)

3) Simple structural design: structural design based on ratio of cross section areas of RCHB walls against floor areas (defined as "wall ratio" in the guideline) without structural calculation using various loads

4) Reinforcing steel bars of small diameter*3 installed in the wall: From the view point of workability on site without large machines, small diameter of reinforcing steel bar (10mm except critical parts such as ends of walls) about every 40 cm both vertical and horizontal direction is recommended.

5) Stack bond: For easy block laying work, stack bond is recommended (no need to raise up blocks above top of vertical rebars to lay blocks with the rebar inside hollows (Figure 11)). The strength of reinforced walls of stack bond is verified to be almost the same as the ones by running bond.

6) Partial grouting: Instead of full grouting of current practice in the Philippines, partial grouting is proposed (only hollows and spaces between blocks where rebars are installed are to be grouted. Figure 11). This method reduces total amount of grout (cement mortar) and provide additional advantage in seismic safety by reducing weight of buildings (dead load).

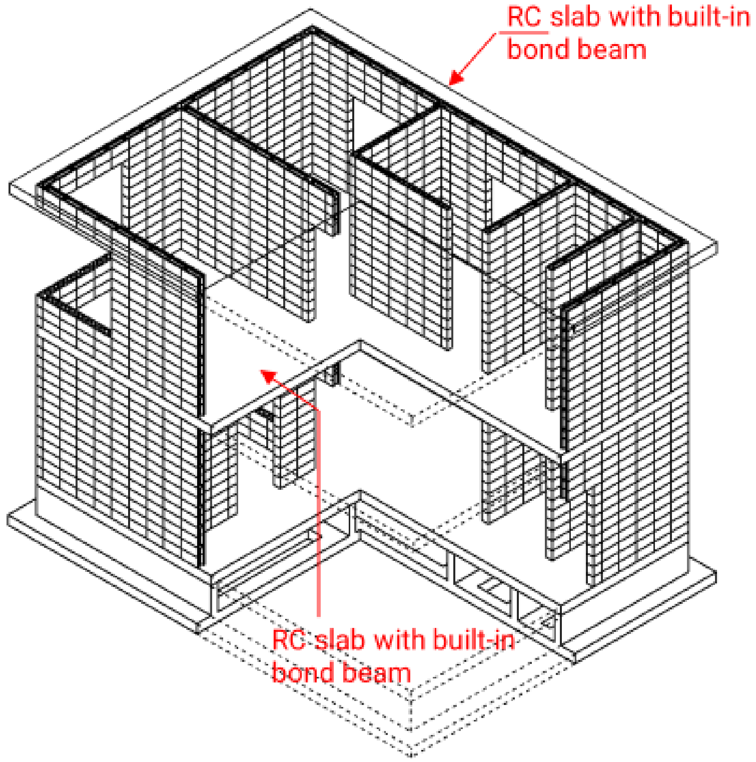

Figure 10 Outline of the proposed load bearing type CHB structure for low-rise buildings.

The figure shows the type of RC slab with build-in bond beam.

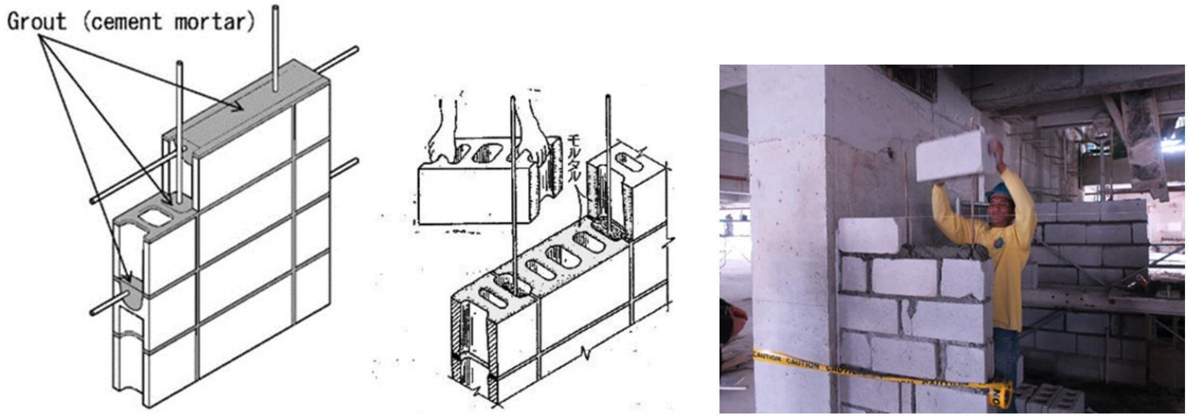

Figure 11 Stack bond is recommended to avoid tough work to lay blocks with the rebar inside hollows.

Left: Only hollows with rebar are grouted (others are left void). Rebars of small diameter are installed at every 40 cm. Centre: block laying work for stack bond (just lay blocks between vertical rebars, Right; current block laying practice to raise blocks above the top of vertical rebar.

3.2.2 Features of the guideline

Features of the propose guideline can be summarized as below.

1) Safe against earthquakes, tsunami, strong winds, and so on

RCHB structures designed and constructed in accordance with the technical guideline using blocks of appropriate quality complying with requirements of product standard (NPS. National Philippine Standard) would be strong against earthquake or other disasters. The Japanese experiences stated in the previous section (1.2 Overview of concrete hollow block technologies in Japan) indicate those have strength similar to RC structures.

2) Simple and practical way of construction

The bearing wall system allows to eliminate RC columns. Simple design of horizontal structural members (slab with built-in bond beam or simple shape beam) would reduce construction work on site such as form panel work for concrete casting. Stack bond eases block laying work. Use of reinforcing steel bar of small diameter makes bending and cutting work easier especially on sites without large machines. All those ways contribute to reduce construction work on site.

3) Simple structural design

The new guideline provides the structural design method far easier than that stipulated in the current structural code (NSCP) using various kinds of loads. With this simple method using “wall ratio”, even engineers who do not have knowledge on structural calculation method using complicated formulas stipulated in NSCP could conduct structural design of CHB construction.

4) Total construction cost

Cost of CHB which meets the new guideline (the Philippine product standard as well) is estimated almost two times more expensive than conventional ones. However, in case of construction based on the new guideline, total amount of cement mortar (bond mortar, plastering mortar and grouting mortar) is far less (Figure 12, 13). Since cement mortar has high mixture ratio of cement and more expensive than CHB, the total cost of construction based on the guideline would be a little less according brief cost estimation (Figure 14).

5) Summary

Comparison of two types of construction (current conventional one in the Philippines and one designed & constructed based on the new guideline) is shown in Table 1. It indicates,

- The strength of the structure based on the new guideline would be far stronger
- Even though the cost of CHB of appropriate quality is estimated almost two times more expensive in case based on the guideline, total construction cost would be a little less because of reduction of cement mortar.

Figure 12 Comparison of CHB. Right: appropriate quality CHB. The shape and dimension are precise.

Left: conventional CHB by small manufactures in the Philippines. The shape is irregular with some fracture at edges and the surface is not flat and smooth, which requires more mortar.

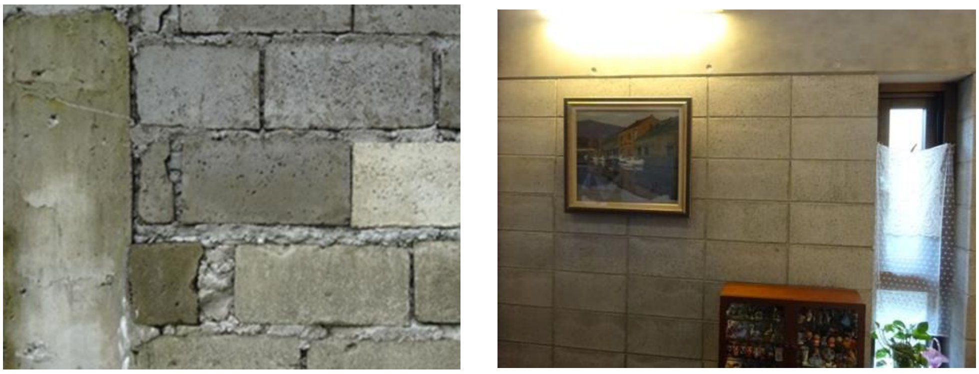

Figure 13 Comparison of CHB construction. Left: conventional CHB construction in the Philippines. It needs thick bond mortar because of irregular shape and unprecise dimension of CHB. The fractured parts need to be filled by mortar. The surface is not flat and smooth, which needs plastering.

Right: Walls of appropriate quality CHB in Japan. The thickness of bond mortar is 10mm. The surface is smooth and beautiful, and does not necessarily need plastering and finishing.

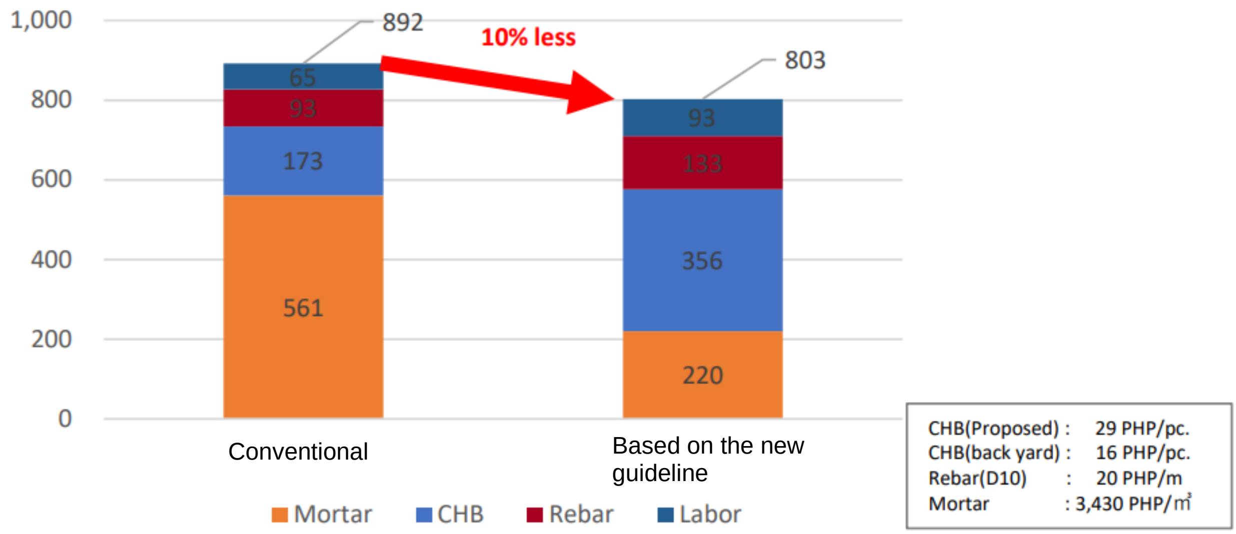

Figure 14 Comparison of total construction cost (unit cost for 1m² in Philippine Pesos). In case of the new guideline the cost of mortar is much reduced whereas the cost of CHB is almost doubled.

Table 1 Comparison of structure based on the new guideline and conventional construction

Items	construction based on the new guideline	conventional construction
strength of CHB	high	low
cost of CHB	**expensive**	**cheap**
shape of CHB	precise	irregular
total cement mortar	**less**	**more**
thickness of bond mortar	around 10 mm	30-40 mm
thickness of plastering mortar	0-10 mm	30-40 mm
grouting mortar	less	more
total cost (mortar, CHB, etc.)	**a little smaller**	**a little larger**
safety of construction	**high**	**low**

3.3 Ways forward to wide use of the technology

1) Formalization of the guidelines and dissemination campaign

The main approach of this project is to disseminate the technology through the building regulatory scheme. In this context, formalization procedures are necessary such as designation by DPWH as a referral code and issuance of official notice on the designation to Building Officials in local governments. For the procedures ASEP and HoBEA invited those relevant persons to the discussion and technical visit to Japan described in the previous section (2.1 Preliminary, surveys, discussions and other activities) and have achieved their good understanding on the technology for smooth designation procedures.

Dissemination campaign is also critical for wide use of the technology. Ordinary activities for dissemination by ASEP such as technical seminars in the capital city and those in regional capital cities in collaboration with branch committee of the ASEP are planned. At the seminars, Building Officials, contractors, developers, NGOs, CHB manufactures and other relevant persons are to be invited.

2) Supports by the other approaches

Along with the main approach through the building regulation, the other approaches should be integrated. For the situation, they also have already involved key persons for each of approaches such as governmental building division in DPWH, National Housing Authorities (in charge of socialized houses), division in charge of Philippine Standard on CHB (Bureau of Philippine Standards/Department of Trade and Industry (BPS/DTI)), leading business persons in business and construction industries such as Philippine Chamber of Commerce and Industries (PCCI), NGOs working on shelters, and so on. In order to achieve the wide use of the technology, comprehensive approach through several channels mentioned above is necessary.

4. Next step activities

4.1 Expansion to other countries

4.1.1 Countries with similar problems of low quality CHB and poor construction work

CHB is widely used in buildings in many countries in the world. Among them, many countries are found to have the similar problems to the Philippines such as low quality CHB and poor construction work (Figure 15). Dissemination of the CHB technology and experience of the collaboration project should be shared and utilized in those countries.

4.1.2 Countries which needs alternative materials to low quality burnt bricks

Another critical issue on building materials is low quality burnt brick. It causes serious problems such as,

1) Inefficient energy consumption by poor performance kills or openair burning

Figure 15 In many countries, CHB is widely used both for small buildings (left) and middle/high rise buildings(right) in Burkina-Faso. There are problems in quality especially blocks manufactured by contractors in construction site (not by manufactures in manufacturing plants) and skills of workers. (Report on the project "Safer CHB Construction in the Philippines", March,2023, Hokkaido Building Engineering Association (HoBEA) 7.3.4 Problems on CHB spreading in wider regions in the world)

Figure 16 Damage in non-structural walls by Gorkha Earthquake 2015. Most of non-structural walls (non-reinforced brick walls) in modern high-rise apartments were damaged. Left: shear cracks in non-structural walls, Right: debris of non-structural wall falling down to the ground

Figure 17 Dhaka, the capital city of Bangladesh, is suffering from serious air pollution caused by small manufactures of burnt brick. The Housing and Building Research Institute (HBRI, a governmental research institute) has been conducting research and development on materials alternative to burnt brick.

Left: trial products of CHB of various types, Right: a manufacturing plant for unburnt brick as an alternative donated by Japan International Cooperation Agency (JICA)

2) Air pollution by non/poor exhaust treatment

3) Erosion of agricultural fields by gathering soil for brick manufacturing

Further, from the view point of earthquake disasters, non-reinforced brick wall is one of the most dangerous issues because it is difficult to install reinforcement within brick walls (Figure 16). For this situation RCHB walls is one of most effective alternatives. For the objective, research and development activities have been conducting in many countries (Figure 17). Dissemination of the technology and experience is expected to be conducted to those countries as well.

5. Concluding remarks

Japan and the Philippines introduced the CHB technology from the US almost at the same time. It evolved in different way in each country and has resulted in the different situations. This project aims to improve the CHB construction in the Philippines with the current technology in Japan based on collaboration and partnership of the engineers of both countries. It has characteristics of comprehensive and practical approach covering from technical aspect to implementation/diffusion of the improved technology on the framework of building regulation in the Philippines. The experience and lesson from this project are expected be utilized for other cases such as countries stated in "4. Next step activities" and further for other types of structures.

6. References

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Notes

*1: Hokkaido Building Engineering Association (HoBEA)

The original organization of HoBEA, "the Hokkaido Building Materials and Concrete Block Association", was establishes in 1952 to improve qualities and technologies relating building materials focusing on concrete block. Since then, they expand the scope of activities and have conducted research activities to develop technologies to create preferable build environment for cold climate of Hokkaido, the northernmost island of Japan.

*2: the guideline and recommended construction methods

The guideline itself allows several construction methods such as full-grout type, running bond, and so on. The construction method explained in this section is a recommended one within the guideline based on Japanese experience considering the acceptability in the Philippines such as cost efficiency, workability on construction site, and so on.

*3: diameter of reinforcing steel bar

Small diameter reinforcing bar is recommended from the viewpoints of 1) workability on construction sites without large machine for cutting and bending, 2) availability in local building material market, and so on. Therefore, spacing of the reinforcing bar is designed to be every 40 cm in usual cases.