DAMAGE CAUSE BY STRONG WIND &
WIND LOADS STANDARD FOR BUILDING
IN VIETNAM

Reported by

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FOREWORD

The purpose of this report would like to show some basic information of typhoon and wind load standard for wind resistant design in Vietnam. Beside, other problems of situation of building structures, using foreign standards, and renovation of Building Code in Vietnam are discussed.
PART I: DAMAGE CAUSE BY STRONG WIND IN VIETNAM

1. OUT LINES OF VIETNAM

1.1. Geographical:

Vietnam is stretch of land strengthening along Indochinese peninsula, which is located in South-east Asia. Mainland stretches from 23°23’ to 08°02’ north latitude and widens from 102°08’ to 109°28’ east longitude. Length counted in straight line from north to south stays at about 1,650 km, width from west to east maximizes at 600 km and minimize at 50 km.

Entire territory of Vietnam includes 329,241 sqr.km of mainland and 1,000,000 sqr.km of territorial sea. Inland border of about 3,730 km, shares its border with People Republic of China in the north with border length of 1,150 km, People’s Democratic of Laos with length of 1,650 km and United Kingdom of Cambodia with length of 930 km in the west. Vietnam has sea border in the east, south and southeast, over the China Sea and Thailand gulf is the republic of Philippines, Indonesia, Singapore, Brunei and United State of Malaysia.

1.2. Topography

Vietnam covers relatively complicated terrain: countless mountains, numerous rivers, stretching and meandering coastline, percentage relation between mountain and plains in mainland area indifferent among regions.

In the northern part, the topography is as follows, three sides of the west, east and north are mountains and hills, south side is coastline and the middle is plain, mainly as the Red and Thaibinh River being consolidated for million years.

Central part is sloping and narrow, its mountains, plains are closing to its coastline. The part is cut and divided by rivers originating from western mountain ranges flowing into the South China Sea. Along the coastline are small plains. Between sloping mountainsides are narrow and deep valleys.

Southern part’s topography is even and flat. Cuulong delta is a low-lying region with average height of about 5m above the sea surface. Some regions of this delta as Longxuyen quadrangle, DongThapMuoi and western Hau River are lower than average sea level, therefore, this area of about 1 million hectares affected by floodwater for 2-4 months per year.

1.3. Climate

Vietnam lies in tropical region, which is meeting place of many atmosphere blocks resulting from continent and Equator Ocean therefore tropical climate of Vietnam deeply suffers from Asia monsoon regime, mainly as northeast and southeast monsoon. However, northeast monsoon is only strong in northern and north central parts so Vietnam enjoys two different climate regions.
The north enjoys two typical seasons: hot season is from May to October and cold season is from November to coming April.

The South is mainly affected by southeast monsoon with heat and wetness round year. Both parts of the country all enjoy different climate sub-region depending on its features of geography and topography position.

There is little difference among regions if temperature is counted averagely as follows Hanoi 24°C (City locates in the north of Vietnam), Hue 25°C (City locates in the midland of Vietnam), Hochiminh City 27°C (City locates in the south of Vietnam), and Dalat 17.6°C (City locates in Central highland of Vietnam). However, there is large difference among months between the north and the south, different temperature in the north is about 10 to 15°C and it is about 2 to 3°C in the south.

There is about 100 rainy days with total amount of rainfall of 1500 > 2000 mm per year in Vietnam.

The humidity always is more than 70% in all locations in Vietnam.


2. NATURAL DISASTER IN VIETNAM
2.1. The frequency of natural disaster:

Vietnam is one of most disaster-prone countries in the world. The tables below describe the relative frequency of deserter in Vietnam (Table 1) and Geographic Areas and Economic Zones of disasters (Table 2).

<table>
<thead>
<tr>
<th>Table 1: Disaster relative frequency in Vietnam can classified as follows [1]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High</strong></td>
</tr>
<tr>
<td>Flood, Inundation</td>
</tr>
<tr>
<td>Typhoon, tropical depression</td>
</tr>
<tr>
<td>Flash flood</td>
</tr>
<tr>
<td>Whirl-Wind</td>
</tr>
<tr>
<td>Drought</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2: Assessment of Disasters Severity in Different Geographic Areas [1]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Natural Disaster</strong></td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>Storm</td>
</tr>
<tr>
<td>Flood</td>
</tr>
<tr>
<td>Flashflood</td>
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<tr>
<td>Whirl-wind</td>
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<tr>
<td>Drought</td>
</tr>
<tr>
<td>Desertification</td>
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<tr>
<td>Saline intrusion</td>
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<tr>
<td>Inundation</td>
</tr>
<tr>
<td>Landslide</td>
</tr>
<tr>
<td>Storm surge</td>
</tr>
<tr>
<td>Fire</td>
</tr>
</tbody>
</table>

Notes: The Table shows the assessment of disaster severity in each zone:
Very severe (++++) Severe (++++) Medium (++) Light (+) None (-)
2.2. Damage assessment caused by disasters for the 10 recent years:


<table>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>People killed</td>
<td>No</td>
<td>508</td>
<td>399</td>
<td>1243</td>
<td>3083</td>
<td>434</td>
<td>901</td>
<td>775</td>
<td>629</td>
<td>389</td>
<td>186</td>
<td>7375</td>
</tr>
<tr>
<td>Houses collapsed</td>
<td>No</td>
<td>7302</td>
<td>11043</td>
<td>96927</td>
<td>100000</td>
<td>12171</td>
<td>52585</td>
<td>12253</td>
<td>10503</td>
<td>9802</td>
<td>4487</td>
<td>395202</td>
</tr>
<tr>
<td>Rice fields submerged</td>
<td>ha</td>
<td>700000</td>
<td>200000</td>
<td>900000</td>
<td>600000</td>
<td>100000</td>
<td>100000</td>
<td>700000</td>
<td>100000</td>
<td>46490</td>
<td>200000</td>
<td>4692313</td>
</tr>
<tr>
<td>Shrimp, fish poll broken</td>
<td>ha</td>
<td>6364</td>
<td>120</td>
<td>4761</td>
<td>34619</td>
<td>215</td>
<td>1419</td>
<td>2877</td>
<td>1002</td>
<td>310</td>
<td>10581</td>
<td>65955</td>
</tr>
<tr>
<td>Ships sunk, damaged</td>
<td>No</td>
<td>43</td>
<td>1117</td>
<td>1017</td>
<td>3008</td>
<td>231</td>
<td>845</td>
<td>109</td>
<td>2033</td>
<td>26</td>
<td>183</td>
<td>11764</td>
</tr>
<tr>
<td>Area of forest fire</td>
<td>Ha</td>
<td>8322</td>
<td>9648</td>
<td>12758</td>
<td>1361</td>
<td>14812</td>
<td>1139</td>
<td>850</td>
<td>1845</td>
<td>15548</td>
<td>1402</td>
<td>115664</td>
</tr>
<tr>
<td>Total</td>
<td>billion-VND</td>
<td>2850</td>
<td>1129</td>
<td>7998</td>
<td>7730</td>
<td>1459</td>
<td>5427</td>
<td>5098</td>
<td>3370</td>
<td>1958</td>
<td>1589</td>
<td>40.835</td>
</tr>
</tbody>
</table>

Note: US$ approximates 15700 VND

Fig. 03: Graph of people killed by natural disaster from 1994-2003 [1]

Fig. 04: Graph of damage cost caused by natural disaster from 1994-2003[1]

Note: 1US$= 15700 VND

2.3. Damage assessment caused by each kind of disasters:

Table 4 showed damage assessment caused by each kind of disaster in Vietnam (Source: The OFDA/CRED International Disaster Database [3]).
Table 4: Summarized Table of natural Disasters in Viet Nam from 1953 to 2004

<table>
<thead>
<tr>
<th>Disaster</th>
<th># of Events</th>
<th>Killed</th>
<th>Injured</th>
<th>Homeless</th>
<th>Affected</th>
<th>Total Affected</th>
<th>Damage-US (000's)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drought</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6,700,000</td>
<td>6,700,000</td>
<td>416,770</td>
</tr>
<tr>
<td>Epidemic</td>
<td>8</td>
<td>1,120</td>
<td>0</td>
<td>0</td>
<td>28,628</td>
<td>28,628</td>
<td>0</td>
</tr>
<tr>
<td>Flood</td>
<td>38</td>
<td>4,413</td>
<td>1,034</td>
<td>316,445</td>
<td>26,972,355</td>
<td>27,289,834</td>
<td>1,320,600</td>
</tr>
<tr>
<td>Insect Infestation</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Slides</td>
<td>5</td>
<td>317</td>
<td>73</td>
<td>39,000</td>
<td>0</td>
<td>39,073</td>
<td>2,300</td>
</tr>
<tr>
<td>Wild Fires</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wind Storm</td>
<td>62</td>
<td>19,831</td>
<td>8,261</td>
<td>3,568,679</td>
<td>34,084,354</td>
<td>37,661,290</td>
<td>1,023,075</td>
</tr>
</tbody>
</table>

Aver. per event:
- Drought: 1,340,000
- Epidemic: 3,579
- Flood: 83,354
- Insect Infestation: 0
- Slides: 0
- Wild Fires: 0
- Wind Storm: 16,501


Table 5: Top 10 Natural Disasters in Viet Nam sorted by numbers of people killed and affected [3]

<table>
<thead>
<tr>
<th>Disaster</th>
<th>Date</th>
<th>Killed</th>
<th>Affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Storm</td>
<td>Nov-64</td>
<td>7,000</td>
<td>9,027,174</td>
</tr>
<tr>
<td>Wind Storm</td>
<td>2-Nov-97</td>
<td>3,682</td>
<td>6,624,710</td>
</tr>
<tr>
<td>Wind Storm</td>
<td>Oct-53</td>
<td>2,300</td>
<td>5,000,000</td>
</tr>
<tr>
<td>Wind Storm</td>
<td>26-Sep-53</td>
<td>1,000</td>
<td>4,635,762</td>
</tr>
<tr>
<td>Wind Storm</td>
<td>23-Oct-85</td>
<td>798</td>
<td>4,079,000</td>
</tr>
<tr>
<td>Wind Storm</td>
<td>25-May-89</td>
<td>751</td>
<td>3,750,000</td>
</tr>
<tr>
<td>Flood</td>
<td>18-Oct-99</td>
<td>622</td>
<td>3,504,412</td>
</tr>
<tr>
<td>Epidemic</td>
<td>1-Jan-64</td>
<td>598</td>
<td>3,000,000</td>
</tr>
<tr>
<td>Wind Storm</td>
<td>24-Jul-96</td>
<td>585</td>
<td>2,800,000</td>
</tr>
<tr>
<td>Wind Storm</td>
<td>Sep-83</td>
<td>578</td>
<td>2,502,502</td>
</tr>
</tbody>
</table>

3. TYPHOON IN VIETNAM

3.1. The frequency of typhoon events in Vietnam:

On average, there were four to six typhoons stroked the coast of Viet Nam every [1 & 4]. However, in many years, Viet Nam is struck by 10 or more typhoons, for instance in 1964 (18 typhoons), 1973 (12 typhoons), 1978 (12 typhoons), and 1989 (10 typhoons).

The areas most affected by typhoons are coastal provinces in the North and Centre of Viet Nam. However, typhoons in the South, though less frequent, can still cause immense damage. At the beginning of the typhoon season, in May and June, typhoons appear mostly in the North. As the typhoon season progresses, the path of the typhoon passes through the country moving towards North to south from May to December (Figure 05).

Typhoons are most frequent in the period from June to October, and are very unpredictable.
3.2. The typhoon tracks

Generally, typhoons begin from South China Sea then move to Vietnam in directions of West, West-North or West-South. Figures 8a, b, and c, d shows the typhoon tracks in 1996, 1997, 1998 and 1999 [2].
3.3. Typhoon damages in Vietnam:

There are only some official summarized statistical documents of Vietnam on damages cause by Typhoon, which made by United Nations Develop Project VIE/97/002- Disaster Management Unit and that are not enough statistical data (e.g. number of killed people, injured people, homeless, economic loss .etc. for each event).

However, all of documents asserted that the damages caused by typhoon are second ranking in Vietnam [1, 2, 3, 4,] but most of top 10 worst damages is caused typhoons (table 5).

Table 6 list damages cause by typhoons and strong wind in Vietnam from 1952 to 2000[4].

<table>
<thead>
<tr>
<th>GLIDE No.</th>
<th>Dis. Subset</th>
<th>Dis. Name</th>
<th>Year/month/day</th>
<th>Killed</th>
<th>Injured</th>
<th>Homeless</th>
<th>Affected</th>
<th>Total of Affected</th>
<th>Damage US$ (’000s)</th>
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<tbody>
<tr>
<td>1 ST-1952-0032-VNM Typhoon 1952/10/..</td>
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<td>2 ST-1953-0019-VNM Typhoon 1953/09/26 1000</td>
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<td>3 ST-1953-0020-VNM Typhoon 1953/10/.. 2300</td>
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<td>4 ST-1956-0050-VNM Typhoon 1956/11/.. 56</td>
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<td>5 ST-1964-0063-VNM Typhoon 1964/11/.. 7000 70000 700000 50000</td>
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<td>6 ST-1971-0029-VNM Typhoon 1971/05/01 23 50000 50000</td>
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<td>7 ST-1971-0057-VNM Typhoon 1971/10/23 89</td>
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<td>8 ST-1973-0047-VNM Typhoon 1973/11/10 100 150000 150000</td>
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<td>9 ST-1977-0088-VNM Typhoon 1977/07/22 1000 1000</td>
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<td>12 ST-1982-0112-VNM Typhoon 1982/10/18 70 290 1300000 1300290</td>
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<td>13 ST-1983-0077-VNM Storm 1983/05/.. 76</td>
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<td>16 ST-1984-0035-VNM Typhoon 1984/04/15 21 94 1000 1094</td>
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<td>17 ST-1984-0103-VNM Typhoon 1984/11/.. 134 289 650416 650705</td>
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<td>18 ST-1985-0114-VNM Typhoon 1985/10/23/ 670 257 225000 225257</td>
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<td>19 ST-1986-0109-VNM Typhoon 1986/09/06 401 2502 2502</td>
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<td>20 ST-1987-0200-VNM Typhoon 1987/11/18 101 352000 352000</td>
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<td>21 ST-1987-0363-VNM Storm 1987/12/.. 22</td>
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<td>22 ST-1988-0460-VNM Typhoon 1988/10/10 101 600000 600000</td>
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<td>23 ST-1988-0503-VNM Typhoon 1988/11/06 20 720000 720000</td>
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<td>24 ST-1989-0104-VNM Typhoon 1989/07/24/ 104 491 491</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32 ST-1991-0711-VNM Storm 1991/03/15 8 10708 10708</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34 ST-1992-0061-VNM Typhoon Chuck 1992/06/29 14 11 2230 44945 47166 400</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35 ST-1992-0143-VNM Typhoon Angela 1992/10/23 17 12 980 31180 32172 18000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37 ST-1993-0133-VNM Storm 1993/03/16 8 16 2000 2016</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38 ST-1993-0231-VNM Typhoon Lola 1993/12/08 73 20 4695 20520 25235</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 ST-1995-0274-VNM Typhoon Zack 1995/11/01 16 51 0 23000 23051 21200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41 ST-1996-0110-VNM Typhoon Franki e &amp; 1996/07/24 585 591 0 386500 387091 362000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 7: Damage Summary caused due to Typhoon Linda (dated report 6th-January 1998)

<table>
<thead>
<tr>
<th>Class</th>
<th>Category</th>
<th>Item</th>
<th>Unit</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humanitarian</td>
<td>People</td>
<td>People killed</td>
<td>No.</td>
<td>778</td>
</tr>
<tr>
<td></td>
<td></td>
<td>People missing</td>
<td>No.</td>
<td>2,123</td>
</tr>
<tr>
<td></td>
<td></td>
<td>People injured</td>
<td>No.</td>
<td>1,232</td>
</tr>
<tr>
<td></td>
<td>Housing</td>
<td>Houses destroyed</td>
<td>No.</td>
<td>312,456</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Houses damaged</td>
<td>No.</td>
<td>34,557</td>
</tr>
<tr>
<td></td>
<td>Education</td>
<td>Schools destroyed</td>
<td>Room</td>
<td>1,424</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Schools damaged</td>
<td>Room</td>
<td>5,727</td>
</tr>
<tr>
<td></td>
<td>Food &amp; Food Production</td>
<td>Agriculture</td>
<td>Paddy Destroyed</td>
<td>Ha.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Paddy damaged</td>
<td>Ha.</td>
<td>71242</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fishery</td>
<td>Boats destroyed</td>
<td>No.</td>
</tr>
<tr>
<td><strong>Total Economic Loss</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>US$ 593,000,000</strong></td>
</tr>
</tbody>
</table>

Notes: In Vietnam (2004), 595 millions USD can build Three Cement Plants (Capacity of 1.4 million ton/year) or built 2.9 million sqr.m of apartment or enough food to supply to 1.5 million persons per year.
3.5. Some examples of typhoon and strong wind damages:

**Damages cause by typhoon**

Fig. 9: A house after Typhoon passed

Fig. 10: ThuaThien- Hue province in typhoon season 1997 (Vietnam Television Agency)

Fig. 11: A picture usually sew in the typhoon season of Central of Vietnam

Fig. 12: A house is collapsed cause by storm No. 2, date 13 June 2004, BinhDinh province and adjacent central provinces. Source: Labor Newspaper Date: 14 June 2004.

Fig. 13: Storm No. 08, Nov-2001 Family of Mr. Huynh Duc Thang, Team 7, section 11, Tranphu-precinct, Quinhon-City

Fig. 14: An R.C. electrical-column are broken cause by storm (Hanoi, 2003).

Fig. 15: Fishing boats broken or sunk due to storm wave Source: Labor Newspapers Date: 11 March 2004.
Fig. 16: Floating-restaurant named Zambo is wrecked cause by storm No. 5, QuangNinh province. Source: Vietnam Net, date 26-August 2003

Fig. 17: A tree fallen cause by storm No. 5, QuangNinh province. Source: Vietnam Net, date 26-August 2003

Fig. 18: A classroom is damaged cause by a whirlwind. Date 20/05/2003- Binhminh- district, Vinhlong province.

Fig. 19: Metal Roofing of a small school had overturned cause by whirlwind. Date 29-May 2004, Quangnam province

Fig. 20: Some wood-house had collapsed Cause by whirlwind. Date 27-March 2005, Nam Dong- suburb of Hue city.

Fig. 21: Tile-roofing of a brick-house had overturned cause by whirlwind. Date 14-Apr 2004, BinhTriDong precinct, TanBinh district - HoChiMinh city

Fig. 22: A glass Window is broken cause by whirlwind. Saigon Super-Market, HoChiMinh city. Source: Vietnam Net date 26–Jun 2003, Glass thickness: 10

Fig. 23: An advertisement column is broken cause by whirlwind. Fortuna Hotel, Langha Street, Hanoi, Source: Vietnam Net, date 03-May 2005.
CONCLUSION

Vietnam is one of the most natural disaster-prone countries in the world and there were a lot of kind of natural disaster such as Flood, Inundation, Typhoon, Tropical depression, Flash flood, Whirl-Wind, Drought, Hail rain, Land slide, Forest fire, Salt water intrusion, Earthquake and other...

The most damage caused by Flood and Strong wind (mainly Typhoon and Whirlwind).

The damage caused by typhoon and other strong wind was serious. However, the database of damage due to strong wind was not enough statistical data of each event. Actually, the professional statistical work only began from 1997.

The Building damage caused by strong wind mainly almost concentrated to small building or small structures, which almost did not built by engineer.

References

[4]. Asian disaster reduction center, website: http://www.adrc.or.jp/
PART II: WIND LOAD STANDARD FOR BUILDING IN VIETNAM

1. SUMMARY

In Vietnam, the current Wind Loading used for Building design is a part of Vietnam-National-Standard, named *Load and Actions- Norm for design* (TCVN 2737-1995), which has valid since 1995 [1]. This load code was originated firstly in 1961, and has four update versions, including (QP 01-61), (TCVN 2737-1978), (TCVN 2737-90) and (TCVN 2737-1995).

The (TCVN 2737-1995) is issued by Ministry of Construction of Vietnam and is mandatory-standard in Construction industry. The outline of (TCVN 2737-1995) shows as follow.

1.1. Scope of applications

(TCVN 2737-1995) stipulates for the Loads and Actions, which used for designing of Structures, Foundation and Buildings.

(TCVN 2737-1995) does not stipulate for the Loads and Actions, which happened cause by the working of railway, motorway, sea-wave, stream-flow, loading and unloading of cargo, earthquake, whirlwind, temperatures, dynamic effect due to running-equipment and others.

With repaired-building, the load using for design-work should be determined by surveying-values on construction site.

Atmosphere effecting has to refer the climatic-values of “Vietnamese-Current-Climatic-Code for design” or values supply by Hydro Meteorological Service of Vietnam (HMSV).

This Norm also does not deal with load and action of very important buildings. This problem will be decided by authoritative-organization (e.g. Government).

Based on (TCVN 2737-1995), other industries as transportation, irrigation (water resource), electricity, post office, etc…Should to make the Private-Load-Standard, which are suitable to their industry.

1.2. Classification of loads

Depend on duration-time of acting, the (TCVN 2737-1995) device loads to 2 types, permanent (frequent) loads and temporary loads (included: long–term, short-term and special load).

The permanent loads include:
- Weights of building (structures, substructures, and other part). This component can understand as dead load in foreign-standards;
- Weight and soil pressure and other (these loads do not change in construction-duration-time or in using-time of building)

The temporary loads:
- The *long-term temporary loads* was defined such detail in this code. Some examples are weight or action of equipment and machines in working-time, effecting of changed temperature or humidity. etc…. The “frequent component of live load” is one of types of long-term temporary loads.
- The *short-term temporary loads* also was defined such detail in this code. Example: weight, materials, and persons in repairing-building-time, acting of equipment and machines in constructing-duration-time, .etc…. The “live load” and “wind load” also knew as short -term temporary loads.
- The *special-loads* includes: earthquake load, exploding load, serious effecting (load) cause by technical and running-equipment (e.g. Loads originated when the car or train rushed to building, etc…), effecting of foundation-deformation when soil-structure was changed caused by landslide, effecting of fire and other…

In summary, (TCVN 2737-1995) stated all kind of loads or actions, which possible happened, and all designers have to consider them in design-work. However, this code mainly guides to estimate of Dead load (D), Live load
(L), Wind load (W) and Crane load (used for industrial-buildings). Seismic load (E) and other actions or effects have to refer another recommendations or specifications.

1.3. Concepts of (Design load) and (Basic load)

In the TCVN 2737-1995, reliability-factor of load understood that is over load factor, denoted by $\gamma$ (normally $\gamma \geq 1.0$). The TCVN 2737-1995 also has instruction for choosing of $\gamma$ and the values depend on purpose of analyzing (e.g. behavior capacity of section, cracking, buckling, deformation, deflection…etc…).

(Design load) = (Basic load) ($\gamma$); where the Basic-load and over load factor are stipulated in (TCVN 2737-1995).

1.4. Combination of Loads

Depend on character of building and the loads and action in considering; the load combination includes basic-load-combination (BLC) and special-load-combination (SLC).

- (BLC) includes (permanent loads) and (long-term temporary loads) and (short-term temporary loads).
- (SLC) includes (permanent loads) and (long-term temporary loads) and (short-term temporary loads may be occurred) and (one of special loads). Generally, (SLC) have to refer another specifications or recommendation.

The loading combination factor, denoted by $\psi$. The (TCVN 2737-1995) also has detailed-instruction for choosing $\psi$ and the value depends on character of building and the number of load type.

The method makes BLC as follows:

- The case has one (permanent load) and the other load (temporary load): $\psi=1.0$ for (permanent load) and (temporary load).
- The case has one (permanent load) and more than two (temporary loads): $\psi=1.0$ for (permanent load) and $\psi=0.9$ for (long-term temporary loads) and (short-term temporary loads).

A simple example of BLC
A new civil building (e.g. office building, school, apartment…etc…) will construct in an area without earthquake and another special actions. There are only acting of dead load, live load and wind load. In this case, two load-combinations using for structural design as follows:

- BLC-1= 1.0D + 1.0L (one frequent load and one temporary load)
- BLC-2= 1.0D + 0.9L + 0.9W (one frequent load and two temporary loads)

Notes: values of 1.0 and 0.9 are combination factors.

2. WIND LOAD OF TCVN 2727-1995

2.1. Outline

In the (TCVN 2737-1995), mean-wind-speed ($V_o$, m/s) using in design depend on the 3-seconds mean wind speed of 10 m height in flat, open country with a return period of 20 years. For calculating of wind load, (TCVN 2737-1995) is divided into 5 zone of wind pressure [1, 2].

This standard shows method to determinate wind load of buildings and other structures that responds elastically in strong wind.

2.2. Wind load definition and scope of application.

According to (TCVN 2737-1995), the wind load includes two component, that are static-pressure component and dynamic-pressure component.

The static -pressure component always must consider in any cases.

The dynamic-pressure component must consider in some cases that satisfy the following criteria:

- High-rise buildings which the height (H) is taller than 40.0 m;
- Frames of one story industrial-building, which the height of building (H) is taller than 36.0 m and the ratio (H/L) is larger than 1.5 (L is span of frame);
- Some flexible and slender buildings, what are sensitive to wind-action (e.g. stack, chimney, power transmission tower, etc…).
- In addition, for more flexible and slender building (or structures) have to check of aero-elastic instability. However, (TCVN2737-1995) has not defined any instruction for this problem and has to refer another specifications or recommendation.

The wind load normally acted on surfaces of building defined as wind force over unit area.

The reliability-factor (over load factor) of wind load (γ), γ=1.2 with assumption-lifetime of building is 50 years. If the lifetime of building is shorter, then could be used the adjust-factor (aₜ) to determine design wind load (see table 7).

\[
\text{Design wind load} = (\text{Basic wind load}) \times (\gamma) \times (aₜ)
\]

<table>
<thead>
<tr>
<th>Assumption lifetime of building (years)</th>
<th>5</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>aₜ</td>
<td>0.61</td>
<td>0.72</td>
<td>0.83</td>
<td>0.91</td>
<td>0.96</td>
<td>1.0</td>
</tr>
</tbody>
</table>

2.3. Determination of basic static pressure of wind load:

2.3.1. Equation

For main structure, claddings and component (element), the “Basic Static Pressure” of wind load should be calculated from equation (5):

\[
W = W₀ \times k \times c
\]  

Where:
- \( W \): basic-static-wind-pressure at height \( z \) (daN/m²);
- \( W₀ \): criteria wind pressure (daN/m²) depending on the location of Vietnam, described in 2.3.2 (criteria wind pressure is terminology in wind pressure map, \( W₀ \) also can understand that is mean wind pressure);
- \( k \): the factor consider to the variation of wind pressure depending on the height \( z \) and terrain category (wind pressure profile factor), described in 2.3.3;
- \( c \): aerodynamic shape factor, described in 2.3.4.

2.3.2. Determination of \( W₀ \)

(TCVN 2737-1995) shows detail of \( W₀ \) value referring to Wind pressure Map (Fig. 24) or administrative location name of Vietnam. The value of \( W₀ \) gets from Table 8.

<table>
<thead>
<tr>
<th>Location in Map</th>
<th>I-A</th>
<th>I-B</th>
<th>II-A</th>
<th>II-B</th>
<th>III-A</th>
<th>III-B</th>
<th>IV-B</th>
<th>V-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>( W₀ ) (daN/m²)</td>
<td>55</td>
<td>65</td>
<td>83</td>
<td>95</td>
<td>110</td>
<td>125</td>
<td>155</td>
<td>185</td>
</tr>
</tbody>
</table>

With locations I-A and I-B, the values in table 8 only used for designing of building in terrains as mountain-areas, hill-areas, plan-areas and valleys-areas. The influence by typhoon is weak in locations of I-A, II-A, III-A.

With complicated terrains as ravines, gulch defiles and other, the \( W₀ \) should be supplied by (HMSV) or should be determined base on equation as follow:

\[
W₀ = (0.5) \times \rho \times V₀^2 \times (0.0613) \times V₀^2
\]

Where:
- \( V₀ \): mean wind speed (m/s) corresponds to the 3-seconds mean wind speed over category B (table 9) at an elevation 10m with a return period of 20 years.
- \( \rho \): air density (1.225 kg/m³) can be used.

If houses or buildings located in the mountain-areas or island-areas which has the same level and category and be placed closed to climate station then should be referred the values of \( W₀ \) what be attached to appendix of TCVN2737-1995.
2.3.3. Determination of k-value

The terrain definition as table 9:

<table>
<thead>
<tr>
<th>Category</th>
<th>Construction site conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Exposed open, no significant obstructions, a few scattered obstructions what the height is less than 1.5 m (e.g. grassland without tall tree, sea, large lake, large river, etc…).</td>
</tr>
<tr>
<td>B</td>
<td>Open, a few scattered obstructions that the height is less than 10 m (e.g. suburb or town that scattered domestic house, villages, thin-forest, sampling-forest, etc…).</td>
</tr>
<tr>
<td>C</td>
<td>Not open, a lot of obstructions close to each other and their height is more than 10 m (e.g. city, dense wood; thick forest…etc…).</td>
</tr>
</tbody>
</table>

Note: With each building, the it’s category (A or B or C) is chosen depend on construction site topography, which do not change in distance of 30h (when H ≤ 60m) or 2 km (when H > 60m) from windward-surfaces of building; H is height of building.

\[ k = 1.884 \left( \frac{z}{z_g} \right)^2 a \]

Category A: \( z_g = 250 \) m; \( a = 0.07 \); Category B: \( z_g = 300 \) m; \( a = 0.09 \); Category C: \( z_g = 400 \) m; \( a = 0.14 \); \( z_g \) is gradient height.

Values of \( k \) should be referred table 10:

<table>
<thead>
<tr>
<th>Height, z(m)</th>
<th>( k )-value depend on each category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A-Category</td>
</tr>
<tr>
<td>3</td>
<td>1.00</td>
</tr>
<tr>
<td>5</td>
<td>1.07</td>
</tr>
<tr>
<td>10</td>
<td>1.18</td>
</tr>
<tr>
<td>15</td>
<td>1.24</td>
</tr>
<tr>
<td>20</td>
<td>1.29</td>
</tr>
<tr>
<td>30</td>
<td>1.37</td>
</tr>
<tr>
<td>40</td>
<td>1.43</td>
</tr>
<tr>
<td>50</td>
<td>1.47</td>
</tr>
<tr>
<td>60</td>
<td>1.51</td>
</tr>
<tr>
<td>80</td>
<td>1.57</td>
</tr>
<tr>
<td>100</td>
<td>1.62</td>
</tr>
<tr>
<td>150</td>
<td>1.72</td>
</tr>
<tr>
<td>200</td>
<td>1.79</td>
</tr>
<tr>
<td>250</td>
<td>1.84</td>
</tr>
<tr>
<td>300</td>
<td>1.84</td>
</tr>
<tr>
<td>350</td>
<td>1.84</td>
</tr>
<tr>
<td>≥400</td>
<td>1.84</td>
</tr>
</tbody>
</table>

Notes:
- With intermediate-level, k-value could determine by elastic-Interpolation-method.
- The different wind directions may be getting the different terrain category.

Fig. 24: Map of Wind pressure regions in Vietnam

Notes:
In the cases what the surrounding building topography are not flat so the height (z) for determining of k should be referred as follows:
- Case 1: If the ground slope, \( i \leq 0.3 \) so height z is calculated by the distance from ground level (the position what building located) to point in considering on building.
- Case 2: If the ground slope, \( 0.3 < i < 2 \) so height z is calculated by the distance from Zo-level (Fig. 25) to point in considering on building.
- Case 3: If the grounds slope, \( 2 \leq i \) so height z is calculated by the distance from Zo-level (Fig. 25) to point in considering on building.
2.3.4. Determination of c-value

2.3.4.1. The c-value for analyzing frame structures

The (TCVN 2737-1995) gives an introduction in diagram, of wind load action and aerodynamics shape factor in detail of 43 typical shapes of building, claddings and element (Refer TCVN 2737-1995, Vietnamese version). In the case, if buildings, structures, and other, in which their shapes are omitted (absented) from (TCVN 2737-1995) then aerodynamics factor have to refer the wind-tunnel-test-results or other recommendations.

The aerodynamic shape factor also is defined external and internal aerodynamics shape factor

An example: determination of aerodynamic shape factor (c) of closed building with roof of two-way slopes in (TCVN 2737-1995).

Note: If the wind blows to gable of building, (direction is orthogonal to the wind direction what showed in Fig. 26) then the values of $C_{e1}$ and $C_{e2}$ are -0.7.
At the zones in building, which the values of external-aerodynamics shape factor is minus, then in strength-component-design has to considering “local pressure”.

In this case: \( c_{local} = c \cdot D \); D=2.0 for ZONE (1) and 1.5 for ZONE (2); see Fig. 27;

Where: D is the factor considering to local pressure. D-factor could ignore if slope angle \( \alpha \leq 10^0 \) (\( \alpha \): see Fig. 26)

Notes: for determinates the total forces on building should not be used D-factor.

2.4. Determination of Basic Dynamic Pressure value of wind load

Based on values of the natural vibration frequency of building in considering (denoted by \( f_1 \) (Hz) for mode s) and the limited value of natural vibration frequency, which is defined in this standard (denoted by \( f_L \) (Hz) and these values shows in table 11), the (TCVN 2737-1995) divides four cases to determine basic dynamic pressure of wind load as follows:

- Case I: \( f_1 > f_L \), see item (2.4.1); \( f_1 \) (Hz) is natural vibration frequency for the first translational mode in along wind direction (mode 1)
- Case II: \( f_1 < f_L \) and the building and component of structures with be analyzed as single-degree-of-freedom system, see item (2.4.2);
- Case III: \( f_1 < f_L < f_2 \), see item (2.4.2); \( f_2 \) (Hz) is natural vibration frequency for the second translational mode in along wind direction (mode 2)
- Case IV: \( f_s < f_L \), see item (2.4.3); \( f_s \) (Hz) is natural vibration frequency for s-th mode in along wind direction (mode s).

2.4.1. Case I (\( f_1 > f_L \))

In this case, the basic wind dynamic pressure (\( W_p \)) should be calculated as follow:

\[
W_p = W \cdot \zeta \cdot \lambda
\]

Where:
- \( W \): basic-static-wind-pressure at height z (daN/m2) is calculated by equation (5);
- \( \zeta \): the dynamic pressure-factor depending on the height (z) and terrain category; the value is referred table 12;
- \( \lambda \): the factor considering to the effect of ratios between surfaces of building (spatial interrelated ration). The surfaces had to considering in analyzing are windward wall, leeward wall, sidewall that received wind load and transfer them to main structures of building (e.g. Frames). (TCVN2737-1995) give out the determination of \( \lambda \) in the case that surfaces of building are rectangular only. In this case, the \( \lambda \)-value is determined base on referring the value of \( \rho \) and \( \nu \) (table 13 and 14). The table 13 shows the definition of \( \rho \) and \( \nu \) when wind direction is X direction (see Fig. 28). Table 14 shows the value of \( \lambda \) in each case of \( \rho \) and \( \nu \).

### Table 11: the limited value of natural frequency

<table>
<thead>
<tr>
<th>Wind-pressure locations</th>
<th>( f_l ) (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-A, I-B</td>
<td>1.1</td>
</tr>
<tr>
<td>II-A, II-B</td>
<td>1.3</td>
</tr>
<tr>
<td>III-A, III-B</td>
<td>1.6</td>
</tr>
<tr>
<td>IV-B</td>
<td>1.7</td>
</tr>
<tr>
<td>V-B</td>
<td>1.9</td>
</tr>
</tbody>
</table>

**Notes:**
- R.C. building, Bick wall building and S.S. building which has surrounded wall, value \( \Delta \) is 0.30;
- S.S. towers, S.S stack or steel truss tower which R.C. foundation, value \( \Delta \) is 0.15;
- \( \Delta \): logarithmic-damping-ratio of vibration

### Table 12: the \( \zeta \)-value

<table>
<thead>
<tr>
<th>Height, z(m)</th>
<th>A-Category</th>
<th>B-Category</th>
<th>C-Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \leq 5 )</td>
<td>0.318</td>
<td>0.517</td>
<td>0.754</td>
</tr>
<tr>
<td>10</td>
<td>0.303</td>
<td>0.486</td>
<td>0.684</td>
</tr>
<tr>
<td>20</td>
<td>0.289</td>
<td>0.457</td>
<td>0.621</td>
</tr>
<tr>
<td>40</td>
<td>0.275</td>
<td>0.429</td>
<td>0.563</td>
</tr>
<tr>
<td>60</td>
<td>0.267</td>
<td>0.414</td>
<td>0.532</td>
</tr>
<tr>
<td>80</td>
<td>0.262</td>
<td>0.403</td>
<td>0.511</td>
</tr>
<tr>
<td>100</td>
<td>0.258</td>
<td>0.395</td>
<td>0.496</td>
</tr>
<tr>
<td>150</td>
<td>0.251</td>
<td>0.381</td>
<td>0.468</td>
</tr>
<tr>
<td>200</td>
<td>0.246</td>
<td>0.371</td>
<td>0.450</td>
</tr>
<tr>
<td>250</td>
<td>0.242</td>
<td>0.364</td>
<td>0.436</td>
</tr>
<tr>
<td>300</td>
<td>0.239</td>
<td>0.358</td>
<td>0.425</td>
</tr>
<tr>
<td>350</td>
<td>0.236</td>
<td>0.353</td>
<td>0.416</td>
</tr>
<tr>
<td>( \geq 480 )</td>
<td>0.231</td>
<td>0.343</td>
<td>0.398</td>
</tr>
</tbody>
</table>

### Table 13: the definitions of \( \rho \) and \( \nu \)

(Wind direction is direction of X-axis)

<table>
<thead>
<tr>
<th>Plan</th>
<th>( \rho )</th>
<th>( \nu )</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZOY</td>
<td>b</td>
<td>h</td>
</tr>
<tr>
<td>ZOX</td>
<td>0.4a</td>
<td>h</td>
</tr>
<tr>
<td>XOY</td>
<td>b</td>
<td>a</td>
</tr>
</tbody>
</table>

**Fig. 28:** The coordinates system is used for determination of \( \lambda \)

### Table 14: the value of \( \lambda \)

<table>
<thead>
<tr>
<th>( \rho ) (m)</th>
<th>5</th>
<th>10</th>
<th>20</th>
<th>40</th>
<th>80</th>
<th>160</th>
<th>350</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>0.96</td>
<td>0.92</td>
<td>0.88</td>
<td>0.83</td>
<td>0.76</td>
<td>0.67</td>
<td>0.56</td>
</tr>
<tr>
<td>5</td>
<td>0.89</td>
<td>0.87</td>
<td>0.84</td>
<td>0.88</td>
<td>0.73</td>
<td>0.65</td>
<td>0.54</td>
</tr>
<tr>
<td>10</td>
<td>0.85</td>
<td>0.84</td>
<td>0.81</td>
<td>0.77</td>
<td>0.71</td>
<td>0.64</td>
<td>0.53</td>
</tr>
<tr>
<td>20</td>
<td>0.80</td>
<td>0.78</td>
<td>0.76</td>
<td>0.73</td>
<td>0.68</td>
<td>0.61</td>
<td>0.51</td>
</tr>
<tr>
<td>40</td>
<td>0.72</td>
<td>0.72</td>
<td>0.70</td>
<td>0.67</td>
<td>0.63</td>
<td>0.57</td>
<td>0.48</td>
</tr>
<tr>
<td>80</td>
<td>0.63</td>
<td>0.63</td>
<td>0.61</td>
<td>0.59</td>
<td>0.56</td>
<td>0.51</td>
<td>0.44</td>
</tr>
<tr>
<td>160</td>
<td>0.53</td>
<td>0.53</td>
<td>0.52</td>
<td>0.50</td>
<td>0.47</td>
<td>0.44</td>
<td>0.38</td>
</tr>
</tbody>
</table>

2.4.2. Case II \( (f_l < f_l) \)

This case applied for buildings and component of structures which analyzing-model is as a single-degree-of-freedom system (e.g. frames of one-story industry building, water tower or other...etc...); the \( W_p \) should be calculated by equation (8) as follows:

\[
W_p = W \cdot \zeta \cdot \nu \cdot \lambda
\]  

**Where:**
- \( W, \zeta, \lambda \): refer equation (7)
2.4.3. **Case III (f_1 < f_L < f_2)**

This case also applied for the buildings have symmetric plan only and f_1 < f_L.

The value of W_p should be calculated by equation (9) as follows:

\[ W_p = m \xi \psi y \]  \hspace{1cm} (9)

**Where:**
- m: weight of building part, which centroid is at height z.
- \( \xi \): the dynamic-factor referring equation (8)
- y: horizontal displacement of building at z-height of mode 1-natural vibration in wind direction. With the buildings has symmetric plan, could use values of y due to cause by horizontal distribution forces.
- \( \psi \): the factor is determined by divides building in height to (r) parts what the wind pressure is constant on each part. \( \psi \) is calculated by equation (10).

\[ \psi = \left( \sum_{k=1}^{r} \frac{W_{pk}}{M_k} \right) / \left( \sum_{k=1}^{r} \frac{Y_k}{M_k} \right) \]  \hspace{1cm} (10)

**Where:**
- \( M_k \) (daN): weight of \( k^{th} \)-part of building;
- \( Y_k \): horizontal displacement of the centroid of \( k^{th} \) building-part of mode 1-natural vibration;
- \( W_{pk} \): uniform basic dynamic pressure of wind load of building-part (k) what be calculated by equation (7)

Otherwise, if buildings have symmetric plan and weight and the windward wide, which are constant in height of building, then \( W_p \) could be calculated by equation (11).

\[ W_p = 1.4 \frac{(z/h)}{\xi} W_{ph} \]  \hspace{1cm} (11)

**Where:**
- \( z, h, \xi \) should be referred above equations;
- \( W_{ph} \): basic dynamic pressure at h-height (top of building) should be calculated by equation (7).

2.4.4. **Case IV (f_s < f_L)**

In this case, the building should analyze in considering to modes of vibration from 1\(^{st}\)-mode to \( s^{th} \)-mode. Where, (s) is defined by requirement as \( f_s < f_L < f_{s+1} \).
2.5. Procedure for estimating design wind loads

The design wind loads is calculated from equation (12)

\[ q = (W + W_p) \gamma a_t A \]  \hspace{1cm} (12)

Where

- \( W \): basic-static-wind-pressure at height \( z \) (daN/m\(^2\)), calculated by the method in (2.3);
- \( W_p \): basic-dynamic-wind-pressure at height \( z \) (daN/m\(^2\)); calculated by the method in (2.4);
- \( \gamma \): over load factor, \( \gamma = 1.2 \);
- \( a_t \): the adjust factor; calculated by the method in (2.2);
- \( A \): projected area at height \( z \) (m\(^2\))

Notes: basic-dynamic-wind pressure (Wp) must be considered in some cases as defined in item (2.2). Besides, Wp is zero.

References

[1]. TCVN 2737-1995, Load and Actions- Norm for design (Vietnamese version);
PART III:  SITUATION ON BUILDING STRUCTURES AND USING FOREIGN STANDARDS IN VIETNAM

1. SITUATION ON BUILDING STRUCTURES
1.1. Outline of solution for Building Structures in Vietnam

In Vietnam, the developing of construction industry depend on characters such as economic level, natural condition, social condition, available material, manufacturing-level, managed and policy system, and others. The solution of building structures are not only depend on above reason, but also depend on some particular characters such as architect solution, designed-level, available material, requirement-time to constructing, and others.

The solutions of building structures had built during last 10 years could be classified as follows:

*Large Span Building* (Gymnasium, Stadium, Large-low-rise-storage, Exhibition hall…) mainly had been used Space-Steel-Truss for Roof and Reinforce Concrete (R.C) or Steel (S) for supporting structures (see Table 15)

*Civil Building* (Hotel, Office, Hospital, Supermarket, Apartment, School, Resident and other…) mainly used R.C Structures (see table 16).

*Light Industrial Building* (textile, food and seafood processing…) normally is low-rise building. The structure had been used S-Structures.

*Heavy Industrial Building* (Building Material, mechanical, metallurgical,…), the using of R.C Structures and S. Structure are multiform and depend on the private character of each projects.

*Besides, in Vietnam there are many Private Resident Buildings (PRB),* which built by themselves (not by Construction Company and engineer). In the big city, PRB mainly made by R.C Structure. In the town and countryside mainly made by brick-wall, wood truss (or S. truss) and tile-roof (or metal-roof). Nowadays, there are only some wood houses in mountain areas and rural areas.

Table 15: Main structural solutions for Large Span Building

<table>
<thead>
<tr>
<th>Main Solutions</th>
<th>Material had been used for Main structures</th>
<th>Roof</th>
<th>Cladding and Surrounding wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundation</td>
<td>Shear-wall</td>
<td>Column</td>
<td>Beam</td>
</tr>
<tr>
<td>R.C Bored pile or R.C. driven pile</td>
<td>R.C</td>
<td>R.C or S</td>
<td>R.C or P.C</td>
</tr>
<tr>
<td>R.C Bored pile or R.C. driven pile</td>
<td>R.C</td>
<td>R.C or S</td>
<td>R.C or P.C</td>
</tr>
</tbody>
</table>

Legend: F: Footing (foundation); R.C: reinforce concrete; S: Steel; P.C: Prestressed Concrete.

Table 16: Main structural solutions for Civil Buildings

<table>
<thead>
<tr>
<th>Number of Stories</th>
<th>Foundation</th>
<th>Material had been used for Main structures</th>
<th>Roof</th>
<th>Cladding and Surrounding wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shear-wall</td>
<td>Column</td>
<td>Beam</td>
<td>Floor slab</td>
<td>S-truss and covering by metal sheets</td>
</tr>
<tr>
<td>1 to 2 stories (5 to 10m)</td>
<td>Brick F or Stone F or R.C F</td>
<td>Brick</td>
<td>Brick or R.C or S</td>
<td>R.C</td>
</tr>
<tr>
<td>3 to 5 stories (12 to 20m)</td>
<td>R.C spread F or R.C raft F</td>
<td>R.C</td>
<td>R.C</td>
<td>R.C</td>
</tr>
<tr>
<td>6 to 12 stories (25 to 50m)</td>
<td>R.C driven pile</td>
<td>R.C</td>
<td>R.C</td>
<td>R.C</td>
</tr>
<tr>
<td>15 to 35 stories (42 to 135m)</td>
<td>R.C Bored pile, R.C Barret Wall</td>
<td>R.C</td>
<td>R.C</td>
<td>R.C</td>
</tr>
</tbody>
</table>

Legend:
- F: Footing (foundation); R.C: reinforce concrete; S: Steel; P.C: Prestressed Concrete.
- Buildings, which are less than 6 stories and beam span more than 7.2m may be using Prestressed Concrete for Beam.
- High rise building, which using flat slabs and without beam, may be using Prestressed Concrete for Slab.
1.2. Tendency and prospects on solution of Building Structures in Vietnam

**Large Span Building:**

Roof structures, mainly, will be used Space-Steel-Truss for Buildings, which has requirement of high aesthetics such as Stadiums, Complex Gymnasiums, Exhibition & Fairs…etc. With other Large Span Building such as Supermarkets, Auto Garages, Large Storages…etc, mainly will be used S-frames.

High strength steel material will use for these building.

**Civil Building** (such as Hotel, Office, Hospital, Supermarket, Apartment, School, Resident and other…)

In next 10 years, mainly will be used R.C- Structures. The Prestressed Concrete Flat Slab will be applied to many Buildings such as Office, Hotel, and Hospital cause by architectural-characters and requirement of shorter-time in construction work.

In next 15 years, mainly will be used S-Structures and Composite-Structures especially in high-rise building (Up to now, there are some projects, which more than 40 stories-height will built in next 5 years and using S-Structure and Composite Structure)

**Industrial Building:** mainly will be used Steel-Structure as much as possible cause by the requirement of shorter-time in construction work.

**Wood (timber) Structures:** only be used in some special cases such as maintaining (repairing) of Pagodas, Temples or traditional cultural buildings, and small-pleasure-house in the spa or beach….

1.3. Some pictures of Building Structures in last 10 years.

In Vietnam, the Architectural characteristic are various in region. There is some typical building in Large Cities or Large Industrial Projects.

**Large Span Buildings**

![Haiphong Exhibition & Fair Building](image)

**Fig. 30: Haiphong Exhibition & Fair Building**

Haiphong City, (Completed 2004)

Total area: 10000 sqr.m. Roof: length-160m, wide-84m, main-span: L=70m. Height: 35-48m.

**Fig. 31: Quan Ngua- Gym.**

Hanoi Capital. (Completed 2004)

Roof Area: 8600 sqr.m; Roof size: Length-100 m, Wide-80 m; Main span: 60m
High-rise Buildings

Up to now, high-rise building (≥ 12 stories) mainly located in Hanoi and HoChiMinh City (Two biggest city in Vietnam). The number of high-rise buildings in Hanoi are more than 30 and HoChiMinh are more than 77 (2004). Beside there are about more than 70 other-underconstruction-highrise buildings.

Fig. 32: A typical low-rise and large span building. (Mainly using for Light Industry in Vietnam)

Fig. 33: Coal Storage- Nghison Cement Plant, Thanhhoa Province (Completed 2000), Area: 8251 sq.m; Span: 53m

Fig. 34: Saigon Trade Center, Office, HoChiMinh City, 33 Stories, Height-145m (Tallest Building in Vietnam, 2004) Completed 1997. R.C and S-Structures.

In the office, trade center or hotel building, mainly surround wall are made by glass.

Fig. 35: ThuanKieu Plaza, Office and Apartment, HoChiMinh City 30 Stories, Height-130 m, Completed 2003. R.C structures, P.C Slabs.

In the apartment buildings, mainly surround wall are made by brick.
Fig. 36: **Typical Structures for Apartment Building**
In Vietnam among last 10 years (6 to 18 stories)
R.C Structures (Shear wall, Columns, Beams and Floor Slab)
Surrounding and Inside Brick Wall

**Low-rise Buildings**

Fig. 37: **Some typical Private Houses** (in Hanoi and HoChiMinh City)
Structures: R.C Frame and R.C Floor Slab and Brick wall
2. SITUATION ON USING FOREIGN STANDARDS AND RENOVATION OF BUILDING CODES IN VIETNAM.

Cause by some historical reasons so there was many Foreign Standards used for Construction works in Vietnam.

2.1. Foreign Standards had used in Vietnam

Before 1975
- In the North of Vietnam had used standards from foreign countries such as Soviet Union (strongest influence), China, Germany (GDR), France, Cuba, and others.
- In the South of Vietnam had used standards from foreign countries such as US (strongest influence) and other Western countries.

After 1975
- From 1975 to 1990, Vietnam used standards from foreign countries such as Soviet Union (strongest influence), China, Germany (GDR), and France, Cuba, Swede, Japan and other.
- From 1990 up to now, Vietnam used standards from foreign countries or organizations such as US, UK, Japan, France, Germany (FRG), Australia, China, Russia, EURO, ISO and others. The strongest influence foreign standards are US, UK, EURO, Japan and ISO.

2.2. Legal documents of allowing of Foreign Standards in Vietnam

Before Construction Law issued (Dec-2003), the Document No. 07/1999/TT-BXD issued by Ministry of Construction (MOC) informed problems of using Foreign Standards in Vietnam. There were only standards of Countries and Organization such as ISO, EURO, US, UK, France, Germany, Russia, Japan and Australia, could be used in Vietnam if got the agreement letter (applied for each project).

Construction Law (Dec-2003), Clause 6 informed that Foreign Standards could be used in Vietnam if got the agreement letter from Authority- Oganiizations. Normally, Ministry of Construction or Ministry of Transportation or Ministry of Industry will decide this problem (depend on character of each Project).


The document No. 09/2005/QD-BXD, also stipulated the Basic Principles of Using Foreign Codes in Vietnam as bellows
- Make sure that Products and Building after construction will be: i) safety for people, building (also for building what located near by the building in considering); ii) Satisfy to Requirements of Ecological and Environmental Conditions of Vietnam; iii) Economical saving.
- Make sure that the synchronism and realizable in all constructive duration (designing, constructing, using, maintaining and other)
- Must be used the data related to some private conditions of Vietnam such as Natural and Climate conditions and Geological conditions and hydrographic conditions and Zoning and intensity of Earthquake
- Must be satisfied to the requirements of current Vietnamese standards.

2.3. Renovation of Standards System in Construction Industry.

Nowadays, Vietnam is mixing with World Trade so the renovation and harmonization of standards become to very important problems. The Vietnamese Government had asked Industries to make a plan to solve this problem.

In Construction Industry, the renovation of standards had been interested early. Duration 1990~2003, there were a lot of meeting to discuss on this problem but no result and deciding in detail.

Date 19th-March 2005, A research project named "Researching on synchronize Vietnamese standards systems in Construction" had finished but not published (Leaded by Prof. Nguyen Van Liem, who also is Vice Minister of Construction). Purposes of this project are giving solution to renovate Vietnamese Standard Systems in Construction, which the tendencies are, innovation and integration with foreign standards (Source: Ministry Of Construction, Website http://www.moc.gov.vn/)

Solution and route:
- One of systems such as EURO Code, Japan Standards and American Standards should be used as fundamental-standards-system for making New-Vietnamese-Building-Code.
- Before 2010, will be published New-Vietnamese-Building-Code (mainly, most strongest influence standards are Principle of Building Design, Load and Action, Reinforce Concrete Structure, Steel Structures, Principle of Foundation Design and other standards using of construction-site-work…) and encourage of using New Vietnamese Building Code.
- Changing and amending of academic books, lectures and other documents in universities.
- Official using of new Vietnamese standards as soon as possible (after 2010).

According to successful in using New-Vietnamese-Building-Code should be cared to some private characteristics of Vietnam such as economical level, available material, un-available material, manufactured level… In addition, the training and retraining for structural designers, student also lecturers in University and other (the persons usually use Building Codes) are very important.

2.4. Some example of Using Foreign Standards for Structural Design in Vietnam

Japanese Standards

Fig. 38: **Binh Bridge - Haiphong City**  
Total length: 1.28 km, Completed 13-May-2005

Fig. 39: **Baichay Bridge – HaLong City**  
Total length: 1.0 km, Will be completed in 2006

Fig. 40: **Thanhtri Bridge, Hanoi Capital**  
Total length: about 5.0 km, Will be completed in 2006

Fig. 41: **Nghison Cement Plant** (1.4million ton/year), Thanhhoa Province, Completed in 2000
**Australia Standards**

Fig. 44: **Mythuan Bridge**,  
Tiengiang-VinhLong Provinces  
Total length: 1.5km, Completed June-2000

**EURO Country Standards**

Fig. 46: **Sofitel Plaza Hotel Hanoi**,  
Hanoi Capital, 20 stories

Fig. 47: **Sheraton Hotel Hanoi**,  
Hanoi Capital, 22 stories
American Standards

Fig. 48: Butson Cement Plant (1.4 million ton/year) Hanam Province, Completed 1997, French Standards

Fig. 49: Holcim Cement Plant (1.6 million ton/year), Kien Giang province

Fig. 48: Butson Cement Plant (1.4 million ton/year) Hanam Province, Completed 1997, French Standards

Fig. 49: Holcim Cement Plant (1.6 million ton/year), Kien Giang province

Fig. 50: Gia Phu Packaging Co., Ltd. A lot of low-rise industry buildings such as above, which made by ZAMIL Steel Com.

Fig. 51: Financial Tower, HoChiMinh City 61 stories, 272m height, steel structures Started work 24-Apr 2005

Combined-Standards

Fig. 52: MYDINH National Stadium 42000 seat, Hanoi Capital Completed 2003. R.C Frames designed by British Standards. Roof Structures designed by Chinese Standards
Russian Standards (Before 1990: Soviet Union Standards)

Fig. 53: **Palace of culture & friendship, Hanoi capital**

Fig. 54: **ThangLong Bridge, Hanoi capital**
Total length: more than 2km

Fig. 55: **HoaBinh Hydroelectric plant, HoaBinh Province**

**CONCLUSION**

During last 10 year, Vietnam mainly used Reinforce concrete Structure in Civil-Building, Steel-Structure in Industrial Building and Large Span Structures.

In the next 10 year, the Steel-Structure will become popular in Construction Industry.

The renovation and harmonization of Vietnam Building Codes are indispensable, especially in order to joint to World Trade. Therefore, solutions and plan solving this problem are very important.