Table 1: Major category approaches in the literature

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No.** | **Author** | **Classification** | **Country** | **Research Method** | **Limitations** |
| 1 | Gibb (2001) | Level 0: Cast-in-situ  Level 1: components and sub-assemblies;  Level 2: non-volumetric pre-assemblies;  Level 3: volumetric pre-assemblies;  Level 4: Modular building | UK | Case study | Difficulty in ascertaining the proportion of prefabrication occupied in a project. |
| 2 | Abosaod (2010) | Complete cast-in-situ;  Sub-assemblies and components;  Panelised frames;  Hybrid systems (semi-volumetric system);  Volumetric systems;  Modules | Turkey | Literature review/data collection and prototyping | The method was highly focused on form-classification without knowing the proportion of prefabrication used. |
| 3 | Sierra and Zamora (2013) | Basic level of prefabrication (LP0)- complete performance on site;  Initial level of prefabrication (LP1);  Advanced level of prefabrication (LP2);  Integral level of prefabrication (LP3). | Spain | Descriptive-technological analysis | Focus was solely on one component of prefabrication: industrialised balcony.  Lacks repeatability |
| 4 | Steinhardt et al. (2014) | Level 0: full in-situ concrete;  Level 1: prefabricated trusses and beams;  Level 2: prefabricated structural panel;  Level 3: specialised pods;  Level 4: modules;  Level 5: fully completed house delivered to sites. | Australia | Case study (Australian builders’ beliefs) | The proportion of prefabrication used in a project was not considered. |

Table 2: Major index approaches in the literature

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Author** | **Method** | **Country** | **Limitations** |
| 1 | CIDB (2004) | Scoring system  Summing up the scores of building elements, including structural systems, wall systems, and simplified construction solutions. | Malaysia | Difficulty with score distribution.  Different forms may be assigned the same score, but their volume of prefabrication may differ. |
| 2 | Alinaitwe et al. (2006) | Ratio of the value of works done on-site to the value of work done. | Uganda | Difficulty in pinpointing the type and form of prefabrication adopted.  Extra effort needed |
| 3 | Wong et al. (2008) | Approximate percentage of the offsite production among all construction components. | Hong Kong | Unable to portray the form of prefabrication adopted in the project  More effort needed |
| 4 | Hong et al. (2016) | Prefabrication volume over the total volume of building materials. | China | Difficulty in knowing the form of prefabrication adopted. |
| 5 | Shamsuzzoha et al. (2018) | Based on potential metrics such as:  Grouping efficiency;  Grouping efficacy;  Grouping capability index;  Utilisation | Oman | Highly dependent on the modularity of the structures with less focus on the geometric shape which may contribute to the volume of prefabrication. |

Table 3: Summary of the strengths and weaknesses of the existing approaches

|  |  |  |
| --- | --- | --- |
|  | **Category Approach** | **Index Approach** |
| **Strengths** | * Clear-cut understanding of the categories of prefabrication * Easy to measure | * Clear-cut understanding of the percentage of prefabrication * Easy to communicate * Can enable a series of numerical tests |
| **Weaknesses** | * The volume of prefabrication is not considered | * Need a lot of effort to collect the data * Form of prefabrication is unknown |

Table 4: Profiles of the selected case projects in Hong Kong

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ID** | **Contract Sum (million HKD)** | **Total Gross Floor Area (m2)** | **Client** | **Year** |
| **P1** | 542.50 | 25,318 | Public | 2015 |
| **P2** | 2,233.00 | 162,398 | Public | 2016 |
| **P3** | 2,580.00 | 183,003 | Public | 2017 |
| **P4** | 2,105.00 | 117,992 | Public | 2016 |
| **P5** | 1,142.80 | 85,773 | Public | 2015 |
| **P6** | 1,232.47 | 120,455 | Public | 2015 |
| **P7** | 2,399.00 | 201,594 | Public | 2019 |
| **P8** | 516.30 | 31,871 | Public | 2016 |
| **P9** | 560.00 | 40,676 | Public | 2017 |
| **P10** | 1,722.00 | 163,755 | Public | 2016 |
| **P11** | 525.00 | 19,410 | Private | 2014 |
| **P12** | 239.88 | 8,432 | Private | 2013 |
| **P13** | 1,767.00 | 128,544 | Private | 2014 |
| **P14** | 179.70 | 7,923 | Private | 2014 |
| **P15** | 3,448.91 | 23,223 | Private | 2014 |

Table 5: Some basic information on the interviews (A-E highly related to the 15 sampled projects)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ID** | **Speciality and Role** | **Years of experience** | **Interview time** | **Place** |
| **A** | Director of one of the biggest precast component suppliers | 20 | May 2020 | Hong Kong, online |
| **B** | Director of a sub-contractor serving private clients | 25 | March 2021 | Hong Kong, Face-to-face |
| **C** | Senior manager in a professional institute | 20 | March 2021 | Hong Kong, online |
| **D** | Architecture background project manager | 15 | May 2021 | Hong Kong, online |
| **E** | Civil engineer background project manager | 18 | May 2021 | Hong Kong, online |
| **F** | Director of one of the biggest precast component suppliers | 22 | May 2021 | Shenzhen, online |

Table 6: Volume-Based Heat Mapping Visualization of the Prefabrication Components by the Authors Based on the Collected Dawings

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Building Components** | **Abbr.** | **Lp** | **Volume (*m3*) per standard construction floor** | | | | | | | | | | | | | | |
| **Public Projects** | | | | | | | | | | **Private Projects** | | | | |
| **P1** | **P2** | **P3** | **P4** | **P5** | **P6** | **P7** | **P8** | **P9** | **P10** | **P11** | **P12** | **P13** | **P14** | **P15** |
| External Structural Wall | ESW | **Level 0** | 25.609 | 6.138 | 16.72 | 195.586 | 20.075 | 20.075 | 10.961 | 42.219 | 14.273 | 10.318 | 8.386 | 17.16 | 14.744 | 10.175 | 4.81 |
| Internal Structural Wall | ISW | 104.402 | 196.914 | 58.405 | \* | 197.23 | 197.23 | 162.063 | 36.682 | 160.6 | 93.547 | \* | 18.48 | \* | 24.207 | 26.944 |
| Concrete Toppings | ICT | 24.181 | \* | 28.326 | 32.807 | 126.808 | 145.337 | 65.353 | \* | 23.574 | 22.889 | \* | \* | \* | \* | \* |
| Landing | CSL | 5.009 | \* | 4.925 | 1.236 | 1.834 | \* | 2.286 | 4.657 | 4.942 | 7.502 | 5.81 | 3.056 | 2.04 | 1.2 | 1.029 |
| Column | ISC | 19.069 | 16.335 | 16.83 | 11.138 | 15.84 | 18.315 | 13.95 | 7.047 | 15.84 | 8.168 | 1.485 | 8.316 | 8.91 | 5.273 | 5.999 |
| Hanger Wall | CHW | 0.401 | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* |
| Full Slab | CFS | 56.008 | 124.974 | 36.555 | 26.42 | 57.499 | 57.581 | 152.386 | 85.417 | 48.373 | 3.613 | 34.351 | 32.96 | 110.703 | 34.814 | 79.866 |
| Beam | CIB | 25.859 | 53.879 | 66.732 | 57.373 | 44.355 | 44.355 | 31.147 | 36.725 | 52.576 | 31.014 | 8.685 | 14.439 | 34.221 | 34.505 | 51.871 |
| Lift Shaft | CLS | 20.603 | 16.236 | 22.506 | 8.723 | 10.367 | 20.734 | 18.095 | 9.423 | 20.048 | 14.366 | 7.304 | 7.304 | 11.1 | 12.471 | 8.393 |
| Staircase | CIS | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | 5.405 | 5.265 | \* | 2.221 | 3.046 |
| Precast beams | PBM | **Level 1** | 9.269 | 0.192 | 0.92 | 4.905 | 2.243 | 4.586 | 1.33 | 4.633 | 8.019 | 2.133 | \* | \* | \* | \* | \* |
| Precast half-landing | PHL | \* | 3.308 | \* | \* | \* | 6.245 | \* | \* | \* | \* | \* | \* | \* | \* | \* |
| Precast R.C. concrete top slab | PTT | \* | \* | 1.186 | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* |
| Full precast slab | FPS | 65.852 | 11.65 | \* | \* | 9.119 | \* | 72.429 | \* | 48.529 | 18.265 | \* | \* | \* | \* | \* |
| Precast lost form | PLF | \* | \* | \* | \* | \* | 4.346 | \* | \* | \* | \* | \* | \* | 6.104 | 35.454 | 41.141 |
| Precast concrete tiles with cement slurry on roof | PTT | \* | \* | \* | \* | \* | \* | \* | \* | 5.749 | \* | \* | \* | \* | \* | \* |
| Precast tie Beam wall | PTB | \* | 0.122 | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* |
| Precast plank | PPK | 5.797 | \* | 28.326 | 25.516 | 98.629 | 80.406 | 46.178 | \* | 19.162 | 18.618 | \* | \* | \* | \* | \* |
| Precast bay window | PBW | \* | 13.54 | \* | 14.518 | \* | \* | \* | \* | 6.979 | \* | 5.02 | 7.68 | 9.454 | \* | 7.384 |
| Precast window frame | PWF | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | 14.45 | \* |
| Semi-precast plank | SPP | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* |
| Semi-precast water tank | SWT | \* | 1.298 | 0.297 | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* |
| Semi-precast structural wall | SSW | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* |
| Semi-precast slabs | SPS | 36.513 | 29.982 | 2.754 | 9.807 | 16.646 | 4.864 | 6.207 | \* | 6.369 | 5.164 | \* | \* | \* | \* | \* |
| Precast façades | PFA | **Level 2** | 111.53 | 38.053 | 67.804 | 28.188 | 38.016 | 55.887 | 57.956 | 23.354 | 27.044 | 124.551 | 11.613 | 49.335 | 40.637 | 83.767 | 31.569 |
| Precast staircases | PSI | 3.489 | 4.678 | 9.604 | 4.814 | 3.246 | 4.05 | 5.107 | 3.776 | 6.768 | 13.265 | \* | \* | 2.426 | \* | \* |
| Precast partition wall | PPW | 5.589 | 12.251 | 7.26 | \* | 2.698 | 5.802 | 4.219 | \* | 2.137 | 2.256 | \* | \* | 21.274 | 3.906 | 7.954 |
| Precast structural walls | PSW | \* | \* | 14.74 | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | 68.569 |
| Non-structural prefabricated external wall | NSW | \* | 11.138 | 4.95 | \* | \* | \* | \* | 3.713 | 18.313 | \* | 41.613 | 19.734 | 24.414 | 124.089 | 13.097 |
| Precast hanger wall | PHW | \* | \* | \* | \* | 14.213 | 16.481 | \* | \* | \* | \* | \* | \* | \* | \* | \* |
| Precast parapet wall | PTW | \* | \* | \* | \* | \* | \* | \* | \* | 2.256 | \* | \* | \* | \* | \* | \* |
| Precast curtain wall | PCW | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | 5.012 | \* | \* | \* | \* |
| precast sunken slab | PSS | \* | \* | \* | \* | \* | \* | 5.843 | \* | \* | \* | \* | \* | \* | \* | \* |
| Precast balconies | PBS | **Level 3** | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | 2.858 | \* | \* |
| Precast bathrooms | PBM | \* | \* | 119.466 | 45.76 | 74.349 | 47.652 | \* | \* | \* | \* | \* | \* | \* | \* | \* |
| Precast kitchens | PHN | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* |
| Precast water tank | PWT | 9.373 | \* | 6.254 | 6.254 | 20.079 | 8.713 | 11.021 | \* | 11.021 | \* | \* | \* | \* | \* | \* |
| Precast refuse chute | PRC | \* | \* | \* | 10.103 | 2.228 | 1.578 | \* | 1.577 | \* | 2.634 | \* | \* | \* | \* | \* |
| Precast planter | PPT | \* | \* | \* | \* | \* | 17.147 | \* | \* | \* | 17.147 | \* | \* | \* | \* | \* |
| Precast fire service water sump tank | PFT |  | \* | \* | \* | 6.208 | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* | \* |
| Precast air-conditioning hood | PCH | \* | \* | \* | \* | \* | \* | \* | \* | 22.65 |  | \* | \* | \* | \* | \* |

Note: P1, P2 …= ID of case projects, \* indicates component not applicable; Lp= Prefabrication Levels according to Gibb’s Taxonomy, Abbreviations derived from OmniClass, UniClass, UniFormat, IfcType, and others.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| High Volume ⇧ |  |  |  |  |  | ⇩ Low Volume |

Table 7: % Volume of Prefabricated Components

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Project ID** | **Volume of Prefabrication (m3)** | **Volume of Cast-in-situ (m3)** | **Construction Volume (m3)** | **% Volume of Prefabrication, per floor** |
| P1 | 281.141 | 247.412 | 528.553 | 46.809 |
| P2 | 414.476 | 126.212 | 540.688 | 23.343 |
| P3 | 250.999 | 263.561 | 514.56 | 51.221 |
| P4 | 333.283 | 156.073 | 489.356 | 31.894 |
| P5 | 474.008 | 281.466 | 755.474 | 37.257 |
| P6 | 503.627 | 257.757 | 761.384 | 33.854 |
| P7 | 456.241 | 210.29 | 666.531 | 31.55 |
| P8 | 222.17 | 37.053 | 259.223 | 14.294 |
| P9 | 340.226 | 184.996 | 525.222 | 35.222 |
| P10 | 191.417 | 204.033 | 395.45 | 51.595 |
| P11 | 71.426 | 63.258 | 134.684 | 46.968 |
| P12 | 106.98 | 76.749 | 183.729 | 41.773 |
| P13 | 181.718 | 107.167 | 288.885 | 37.097 |
| P14 | 124.866 | 261.666 | 386.532 | 67.696 |
| P15 | 181.958 | 169.714 | 351.672 | 48.259 |

Table 8: Correlation between the Prefabrication Levels

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Level 0** | **Level 1** | **Level 2** | **Level 3** |
| **Level 0** | 1 |  |  |  |
| **Level 1** | 0.799 | 1 |  |  |
| **Level 2** | -0.334 | 0.025 | 1 |  |
| **Level 3** | 0.579 | 0.179 | -0.038 | 1 |