ApPlyWood

ApPlyWood / Version 1
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Aim of the software

The purpose of this software is to estimate the in-plane seismic response of timber diaphragms retrofitted with plywood panels fastened along their perimeter to the existing sheathing. The program can support professional engineers in the preliminary design and dimensioning of plywood-based seismic retrofitting interventions on timber floors in existing buildings.

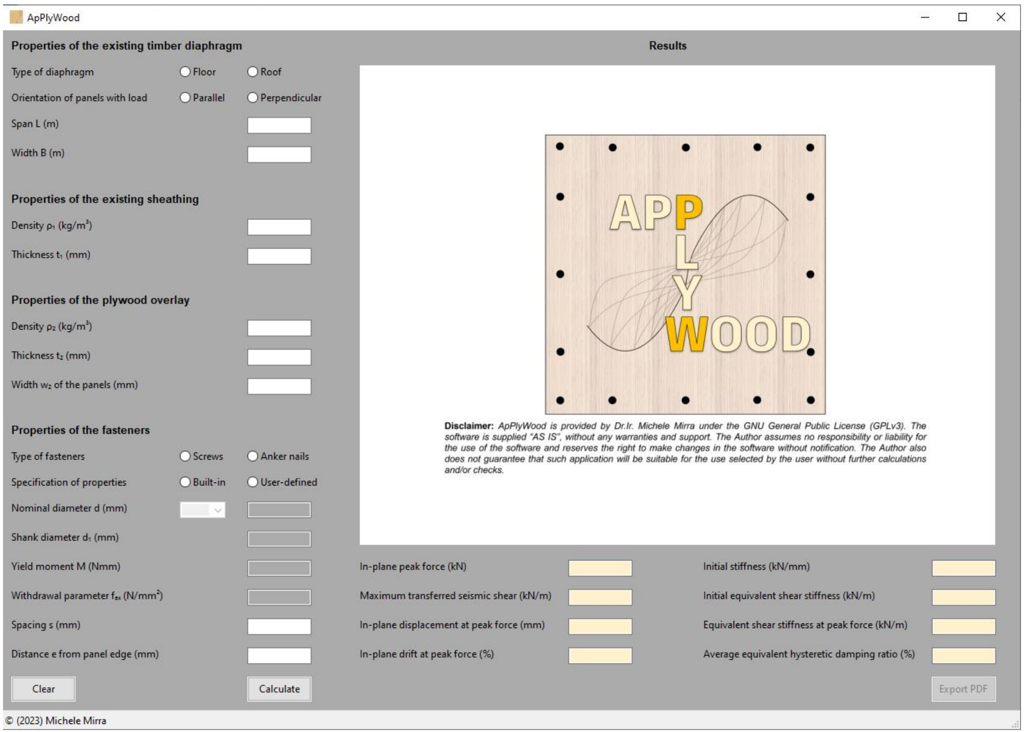
General information and requirements

The software was created using `Python` programming language and is made available as script optimized for Windows (`ApPlyWood_Windows.py`) or Mac OS (`ApPlyWood_MacOS.py`), as well as standalone executable file (`ApPlyWood.exe`, for Windows only). Along with these files and the `README.pdf` document, eight images (`.png`) and one icon (`.ico`) are also present in the package, and are needed for the functioning of the user interface of the software, thus they should all be located in its same folder. Please note that, in order to run the scripts, you need to have installed `Python` on your computer, along with its modules `wx`, `matplotlib`, `math`, `numpy`, `scipy`, `fpdf`, and `datetime`. This requirement does not apply if you run the standalone executable file `ApPlyWood.exe`.

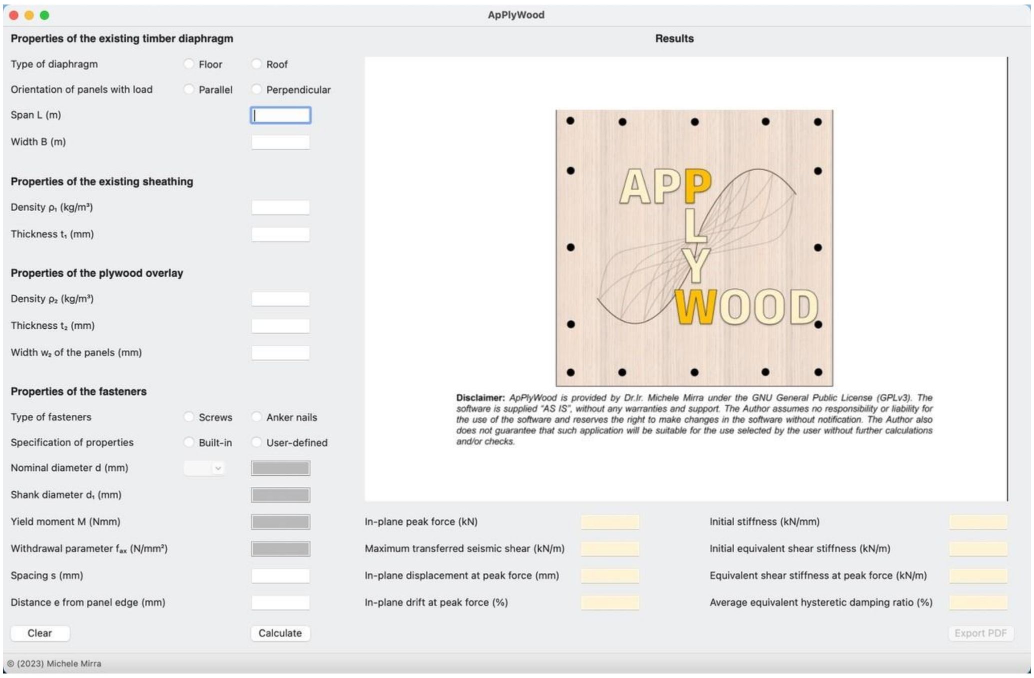
How to run and use *ApPlyWood*

After downloading the `.zip` archive, extract it as folder in a location of your choice. Due to the presence of an executable file, it might happen in few cases that this is not considered as legitimate by the installed antivirus. Should this issue occur, indicate that `ApPlyWood.exe` is a legitimate file in your antivirus settings.

On a Windows computer, running `ApPlyWood.exe` or launching `ApPlyWood_Windows.py` from the terminal will open the following graphical user interface (optimally shown when Windows display settings for text size is set at the recommended value of 100%):



On a MacOS computer, launching `ApPlyWood_MacOS.py` from the terminal will open the following graphical user interface:



The user needs to first specify the type of diaphragm (floor or roof; in the latter case, the span to be specified is the inclined length of one in-plane loaded pitch), the panel orientation with respect to the load (parallel or perpendicular), and the main dimensions *L* and *B*. During the selection, a schematic picture of the diaphragm appears, to help the user specify all required parameters.

Next, the material and geometrical properties of both existing sheathing and plywood panels have to be inserted, followed by the characteristics of the fasteners. In this case, the user can specify the use of screws or Anker nails, and can refer to built-in properties (based on available technical data [1]), or user-defined ones, to be manually input. Finally, the spacing and distance from panel edge of the selected fasteners have to be inserted. An example of data input and calculation is reported on page 3.

To determine the in-plane behaviour of the diaphragm, press the `Calculate` button. Should an input parameter be missing for any reason, the bottom status bar will indicate it. Otherwise, a graph showing the in-plane response of the floor appears, calculated by means of the analytical model [2, 3, 4] implemented in the software. Subsequently, the bottom status bar indicates the statement `In-plane response of the diaphragm successfully determined`, and the button `Export PDF` is enabled (see screenshot reported on page 4). This allows the user to save a one-page PDF report of the graph with the main output values. Finally, the button `Clear` allows to clear all fields and restart with another calculation.

Reference publications

[1] Rotho Blaas Srl (2023). *Timber screws and deck fastening*. Technical data catalogue, Cortaccia, Italy. Available at https://www.rothoblaas.com/catalogues-rothoblaas.

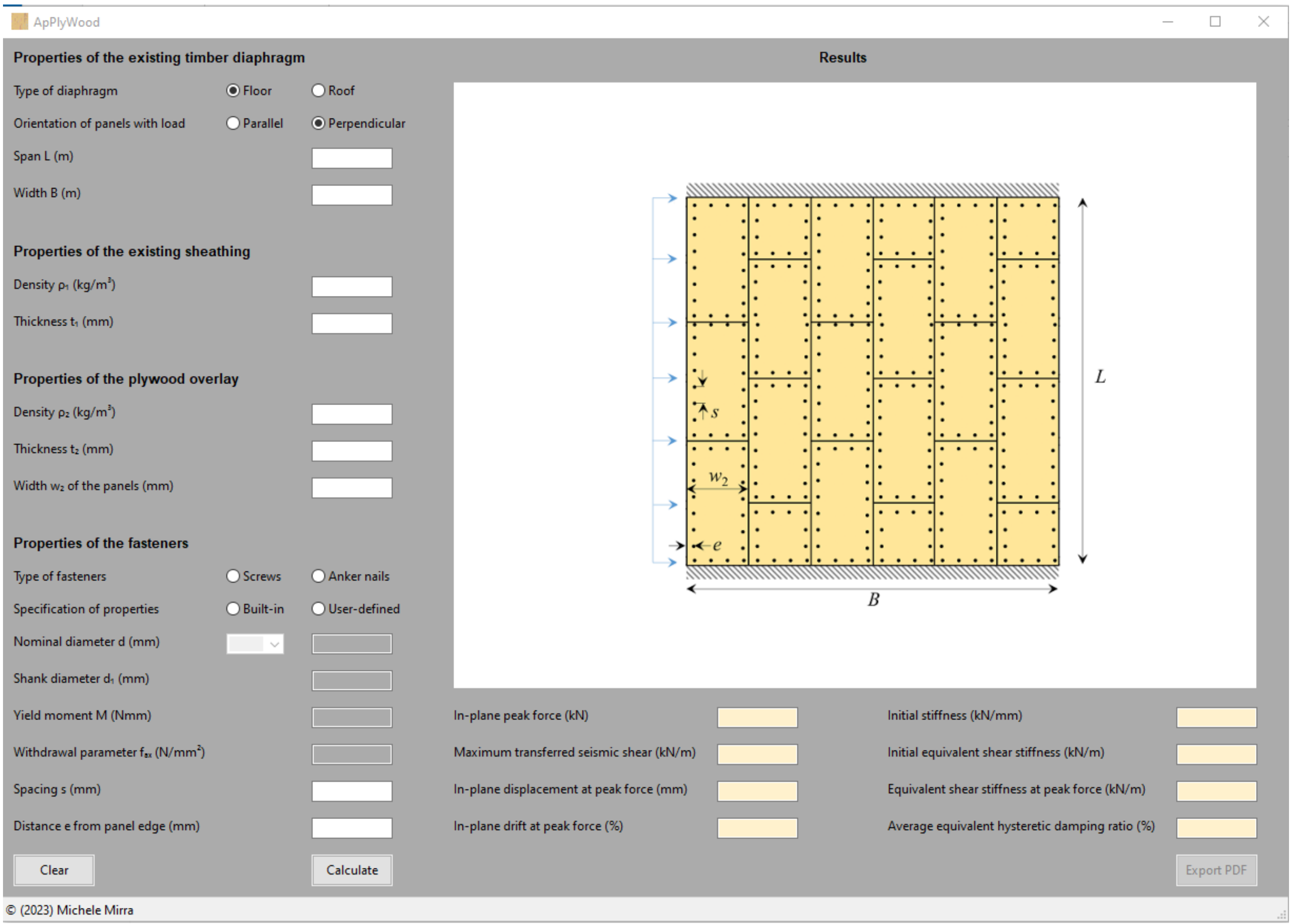
[2] Mirra M., Ravenshorst G., de Vries P., van de Kuilen J.W. (2021). An analytical model describing the in-plane behaviour of timber diaphragms strengthened with plywood panels. *Engineering Structures*, 235: 112128. https://doi.org/10.1016/j.engstruct.2021.112128.

[3] Mirra M., Sousamli M., Longo M., Ravenshorst G. (2021). Analytical and numerical modelling of the in-plane response of timber diaphragms retrofitted with plywood panels. *8th International Conference on Computational Methods in Structural Dynamics and Earthquake Engineering*, COMPDYN 2021, Athens, Greece. https://2021.compdyn.org/proceedings/pdf/18731.pdf.

[4] Mirra, M. (2022). *Seismic behaviour of masonry buildings with timber diaphragms*. PhD dissertation, TU Delft, ISBN 978-94-6421-710-0. https://doi.org/10.4233/uuid:e2fdb0c4-a80d-49c7-889c-7e492fb20ca3.

Calculation example

Firstly, type of floor and panels' orientation with respect to load have to be specified; the software also provides a picture to better identify the input parameters. For example, the figure below shows what happens when the type of diaphragm *Floor* is selected, with panels having their long side *perpendicular* to the in-plane distributed load.



Next, the span L has to be specified (in m; this is the dimension orthogonal to the in-plane distributed load), along with the width B (in m; this is the dimension orthogonal to the in-plane distributed load).

Then, the properties of the existing sheathing have to be provided, and namely the density (in kg/m^3, usually between 350 and 550 kg/m^3 for typical softwood floors) and the thickness (in mm, typically between 15 and 30 mm).

Subsequently, the user needs to input the properties of the plywood overlay: the density (in kg/m^3, usually between 450 and 600 kg/m^3), the thickness (in mm, typically between 9 and 30 mm) and the width (in mm; this is the dimension of the panel's short side and can be equal to the standard width of 1200 mm, or a lower value (e.g. 600 mm).

Finally, the fasteners' properties have to be specified. First, it is necessary to choose between *screws* and *Anker nails*. Next, the user needs to select whether the input properties are those already incorporated in the software (*built-in*) or are to be specified manually (*user-defined*). In the first case, a drop-down menu is enabled, allowing the user to select the built-in fastener diameters, and the properties *nominal diameter*, *shank diameter*, *yield moment* and *withdrawal parameter* are filled automatically. In the second case, all cells referred to these properties become editable, and the relevant values can be manually provided, based on the technical data of the chosen producer. As final step, the fasteners' spacing and distance from panel edge needs to be inserted.

By pressing the `Calculate` button, the estimated in-plane response of the retrofitted floor appears (see screenshot on page 4). To change only some input parameters, it is not necessary to press the `Clear` button and clear all fields, but just to substitute the relevant value(s) and press again the `Calculate` button. As mentioned before, a PDF report can also be exported, containing a summary of the input properties and an overview of the output parameters: the global peak force $F_{max,floor}$ (kN), its associated transferred seismic shear at supports $v = F_{max,floor}/(2B)$ (kN/m), the corresponding displacement $d_{max,floor}$ (mm) along with the drift γ (%), the initial stiffness $K_{0,floor}$ (kN/mm) and corresponding initial equivalent shear stiffness $G_{d,0}$ (kN/m), the equivalent shear stiffness at peak force G_d (kN/m), and the average equivalent hysteretic damping ratio (calculated with the energy loss per cycle method) over all inner pinching cycles (%).