

## A LOADS-INTERACTION APP FOR THE STRUCTURAL ELEMENTS OF A BUILDING USING ARCGIS INSTANT TOOLS

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### ABSTRACT:

A major topic that is focused on the potential difficulties and safety considerations associated with adding an additional storey is the effect of a building's dead loads on its foundations. It is important to take into account the constraints imposed by the current building loads as well as any dangers or concerns related to structural integrity when deciding whether or not such an expansion is practical or allowed. However, if an interactive map displaying the weights of the walls and their computations is provided, stakeholders and decision-makers will decide correctly to add another level to the building. Therefore, with the advancement of technology and the demands of modern living, an interactive maps app for showing building loads and its capability to rapidly and precisely visualise spatial data linked to structural stress, safety concerns, and capacity usage has become essential. The objective of this study is to develop an immediate app that allows viewers to explore more details about calculating the dead loads of the building and their impacts on its structure. Our new approach shows a detailed map of the various load values together with supplementary text that offers further information. The loads-interactive App can also help in surfing map layers so that users can examine and better understand the computation of the building's dead loads. The outputs of our promising method illustrate the importance of interactive map applications in facilitating accurate calculations of building loads.

### 1. INTRODUCTION

In a situation like assessing the viability of building an additional storey onto an existing structure, the effect of dead loads on the foundations of the building is a critical factor. When the overall load constraints raise potential safety concerns, this evaluation becomes very crucial. Receiving extra weight can impede the safe addition of another storey due to the total building loads. Therefore, the calculations of the building loads are an important issue that should be taken into account in order to evaluate the additional allowable structure's dead loads on the building itself and its foundations. The inclusion of such computations in an interactive app encourages effective resource management and allocation while reducing the possibility of overloading and subsequent structural problems. In this vein, if an interactive map is accessible depicting the weights of the walls and their computations, stakeholders and decision-makers will be able to make the best choice about the building's addition of another storey. Hence, the creation of an engineering mobile and web App to display the building loads can be useful in terms of enhanced visualization, improved decision-making, collaboration, accessibility, and ease of use with modern user interfaces. The goal of this research is to develop a mobile and web application that will assess the building's current total loads and interactively display the loads' calculations to enable quicker decision-making regarding maintenance, restoration, or expansion projects.

The remaining sections of the paper are arranged as follows. The relevant work is presented in Section 2. Section 3 goes into detail about our methodology. In Section 4, we report the results of our experiments for a particular campus building, and in Section 5, we draw some important conclusions.

### 2. RELATED WORK

A cutting-edge mobile application enables effective communication among stakeholders by presenting complex data in an easy-to-understand manner. With the help of cutting-edge configurations and engineering principles, this application precisely display the calculations of the weight resulting from the wall's own weight. Users can quickly determine the dead loads for a structure's walls by entering significant information, such as measurements, materials, and other important parameters. This improves decision-making in architectural design and construction projects.

In this context, the creation of interactive map apps for calculating building loads has attracted a lot of interest in the scientific community in recent years. A number of publications have aided in the development of this discipline by showcasing the tools' potential to improve building design and energy efficiency. A case study of an interactive map application created to estimate the heat loads of existing residential buildings was provided by (Chen et al., 2018). They showed how combining geographical information, thermal imaging analysis, and building geometry may produce a trustworthy tool for enhancing retrofit plans and lowering overall energy consumption. In another study, With a GIS-focused database system, (Özbay et al., 2020) have devised a method to arrange and display the outcomes of a visual screening strategy for evaluating the seismic risk of reinforced concrete buildings. The findings showed that it is strongly advised to make mobile data transmission in the field as a developed tool and visualisation in GIS a standard component of the seismic evaluation procedure. In recent years, (Odion et al., 2023) offered a step-by-step procedure for creating an interactive web Geographic Information System (GIS) tool that compiles and displays open-source datasets for the aim of monitoring food supplies. An

additional research study, (Gorsevski, 2023) presented an interactive web-based method for simulating the vulnerability to rainfall-induced landslides using free and open-source software. The author recommended that local planning could benefit from using their projected landslide potential as a decision-support tool. The associated efforts that were previously discussed emphasize the value of interactive map applications in enabling precise calculations for any engineering project, environmental project, or other project. However, the function of correlating ArcGIS technology, including the tools and Apps, in civil projects and engineering activities in general has received very little attention up to this point. The usage of ArcGIS Instant Apps to depict the building's loads for potential development expansion is the main emphasis of this research. The cutting-edge ArcGIS tools and Apps may have played a crucial role in encouraging the building's operational effectiveness and pointing architects and engineers in the direction of sustainable building design practices.

### 3. THE METHOD

In our approach, we concentrated on the creation of an application that is simple to use and has a clear display for calculating the dead loads of building walls. This cutting-edge app provides accurate calculations by taking into account a number of variables, including wall dimensions, material densities, and other pertinent structural aspects. Our load-interaction app aims to facilitate effective structural analysis, increase the overall productivity of engineers and architects in their building design projects, and maintain the existing buildings by streamlining the load determination procedure. An overview of the workflow is shown in Figure 1 to provide a summary of the approach.

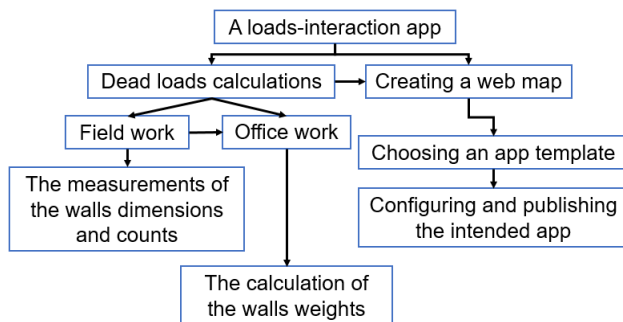


Figure 1. The proposed method's workflow.

#### 3.1 Dead Loads Computations

The weight of the permanent elements, such as beams, floor slabs, columns, and walls, causes dead load on a structure. Throughout the lifespan of the structure, these components will consistently create the same amount of "dead" load. The vertical plane is the location of dead loads. The dead loads of the building's walls can be computed as follows:

Dead load = the member's volume × the material's unit weight.

An exact dead load can be calculated for each component by determining the volume of each member and multiplying it by the unit weight of the materials from which it is made. Our situation involves a campus facility that houses the civil engineering department.

To determine the dead loads of the walls, we took the following steps:

- Determine the dimensions of the building's walls (Length, Height, Thickness)
- Calculate the wall's surface area (Length x Height)
- Determine the type of material used in the walls (e.g., concrete, brick, wood), in our case the wall material of the selected building was concrete (2.4 g/cm<sup>3</sup> Density)
- Obtain the unit weight of the chosen material (typically in lbs/ft<sup>3</sup> or kN/m<sup>3</sup>)
- Multiply wall's surface area by its thickness to get volume (Area x Thickness), in our case the value of the thickness is 0.2 cm
- Calculate the dead load by multiplying wall's volume by unit weight (Volume x Unit Weight)
- Add up dead loads of all walls in the building

#### 3.2 Creating and Publishing App

We used Instant App templates for creating the load-interaction app. The steps in building our app are illustrated in Figure 2.

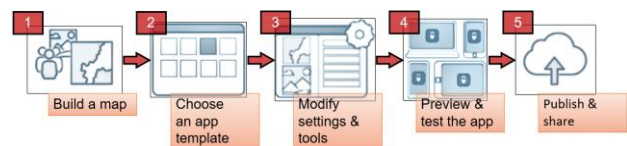


Figure 2. An App's development and publication in the five-step approach.

The express setup was applied to configure the load-interaction app with these essential five procedures. Initially, 2D designs were produced for the two-story building that housed the civil engineering department. The two maps were then converted from plans. Following the georeferencing procedure, we were able to identify the exact location of each plan's two storeys and the complete building on the imagery basemap. The values for the building's walls' dead loads have been added to the table of the attributes for the two floors. After then, each floor map's walls were individually represented by a distinct colour using a colour scheme to indicate whether or not they were structurally constructed with a door, window, or both. The two maps were then exported into a hosted feature layer that could be edited in ArcGIS Online. To give a targeted user experience for understanding how the building dead loads can be computed, we chose an app template using Instant Apps in the second step of the app construction process. This decision was made based on our data, goals, and intended audience. Because it can offer the side panel hosts the tools for interacting with the map, descriptions of the app, and data from map information, and because it can be configured to display pop-up windows and other common choices like a legend and bookmarks, the Sidebar App was chosen to accomplish the current study's objectives. Thirdly, we added features, changed the design, and added messaging while adjusting settings and tools. The tools in the side panel are simple to edit, show, and hide because of the app setup. The side panel tools can be used to set up the following: (1) a layer list (providing options to show or hide

layers in the map); (2) the basemap gallery (providing a collection of basemaps to let users see the map in various contexts); and (3) Edit tools (providing options to add, delete, and update features in a map that includes an editable layer). Previewing and testing the loads-interaction app is the fourth stage after that. Instant Apps instantly updates the app preview as we adjust the aforementioned settings and stores the modifications as a draft. To test the end-user experience, users can explore within the preview or publish and open the app in a new window. Finally, our app has been released and distributed to the intended audience. Our App is publicly accessible: <https://nk21.maps.arcgis.com/apps/instant/sidebar/index.html?appid=afa5bbc89ec94f3098e73f47df3dff4d>  
The other one that will work is the generic ArcGIS.com URL: <https://www.arcgis.com/apps/instant/sidebar/index.html?appid=afa5bbc89ec94f3098e73f47df3dff4d>

## 4. RESULTS AND DISCUSSION

### 4.1 The Weight of Materials of Construction

In this section, the calculations of dead loads of the Civil Engineering Department building of the ground and first floors are given in Table 1 and Table 2, respectively. We noted that our suggested method effectively estimated the dead loads for various building structures. The investigation showed that the computation approach performed consistently and reliably, with a tolerable maximum error rate by experts. Additionally, our results demonstrate that because these components were measured directly, including material and structural component differences allowed for a dead load prediction that was more accurate. The plans and paperwork for the current building were also compared with our computations of the weights, and the results showed that our assessment was remarkable in terms of correctness and computational effectiveness. Therefore, our study reveals that the fair calculation method for building dead loads could significantly help structural design and safety considerations in future construction projects as well as sustainability and maintenance of the building, particularly when the building is already there and does not have the original construction design's plans and documentation.

**4.1.1 Existing Dead Loads:** Tables 1 and 2 of the two-story structure show the results of the measurements of the dead loads. To determine the dead loads of each floor and ultimately estimate the entire structure, the weights of the building's walls were added together.

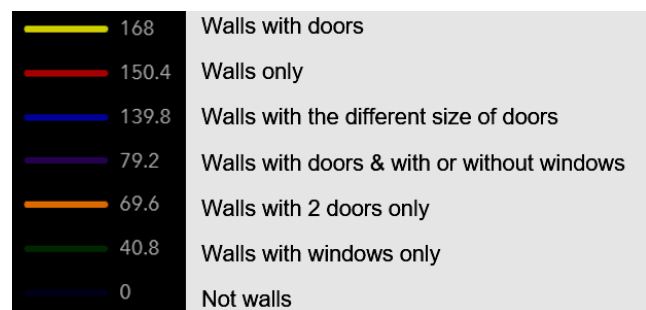
Ground Floor			
Class	Dead load for each type of the structural components (kN/m <sup>3</sup> )	No.	Total weight (kN/m <sup>3</sup> )
A	168.0	6	1,008.0
B	150.4	9	1,353.6
C	139.8	7	978.6
D	79.2	8	633.6
E	69.6	2	139.2
F	40.8	5	204.0
G	No weight	-	-
Sum			4,317.00

**Table 1.** Dead loads of the ground floor of the building.

First Floor			
Class	Dead load for each type of the structural components (kN/m <sup>3</sup> )	No.	Total weight (kN/m <sup>3</sup> )
A	168.0	6	1,008.0
B	150.4	9	1,353.6
C	139.8	7	978.6
D	79.2	9	712.8
E	69.6	2	139.2
F	40.8	5	204.0
G	No weight	-	-
Sum			4,396.20

**Table 2.** Dead loads of the first floor of the building.

Our calculations revealed that if the walls have fenestration, such as windows and doors, as illustrated in Figure 3, the load values of the walls change depending on how the wall is installed. The arrangement of windows in a building is concerned with the layout, construction, and design of windows and doors in a structure.



**Figure 3.** The two-story building's load-bearing wall classification using ArcGIS Pro.

**4.1.2 A loads-Interaction App:** Redrawing the 2D drawings for the current structure is an option. Direct measurements of the building's size will be necessary if the building blueprints are absent, though. As noted in the preceding section, as a first step in designing our app, we redrew the two-floor layouts of the building for use in creating maps for mobile and online apps.

By georeferencing the building's plans with the use of ArcGIS Pro's georeferencing capabilities, Figure depicts the building's actual geographic position. We symbolised every wall in every story of the building based on the dead load values of its walls, as seen in Figure 4. For the purpose of creating a hosted feature layer that can be edited using ArcGIS Online, the two layers and their associated properties were exported as a geodatabase feature class. In terms of colour scheme, the map style is still distinct from the original map that was made using ArcGIS Pro. By using ArcGIS Instant Apps, the loads-interaction app was created and configured as shown in Figure 5. The final results are displayed in Figure 6 and Figure 7. When any application needs to be customised, Instant Apps provides a simple setup

option in addition to a collection of up-to-date no-code app templates.



**Figure 4.** The 2D plans of the building's ground and first floors.

Nevertheless, there are restrictions on how these templates can be set up, and it doesn't allow us to edit the Instant Apps templates. Particularly, the Sidebar App template won't be useful if we try to use it simply for calculations of live and dead loads (civil engineering projects) without relying on the spatially associated map attributes. We can verify that ArcGIS Instant Apps templates are a valuable tool for quickly constructing Apps using a range of spatial maps. Despite the fact that we could only use a subset of the App's functionality, it was difficult to display all of the load calculations' equations, for instance. However, the user-friendly interface and effective design of our produced App allow engineers to work more productively and accomplish their goals more quickly. The rising use of mobile gadgets in today's society must also be taken into account and employ such technology for a better understanding of spatial characteristics and relationships between different environmental and engineering projects. Even though there has been a lot of advancement, there is still potential for improvement and more research in this field.

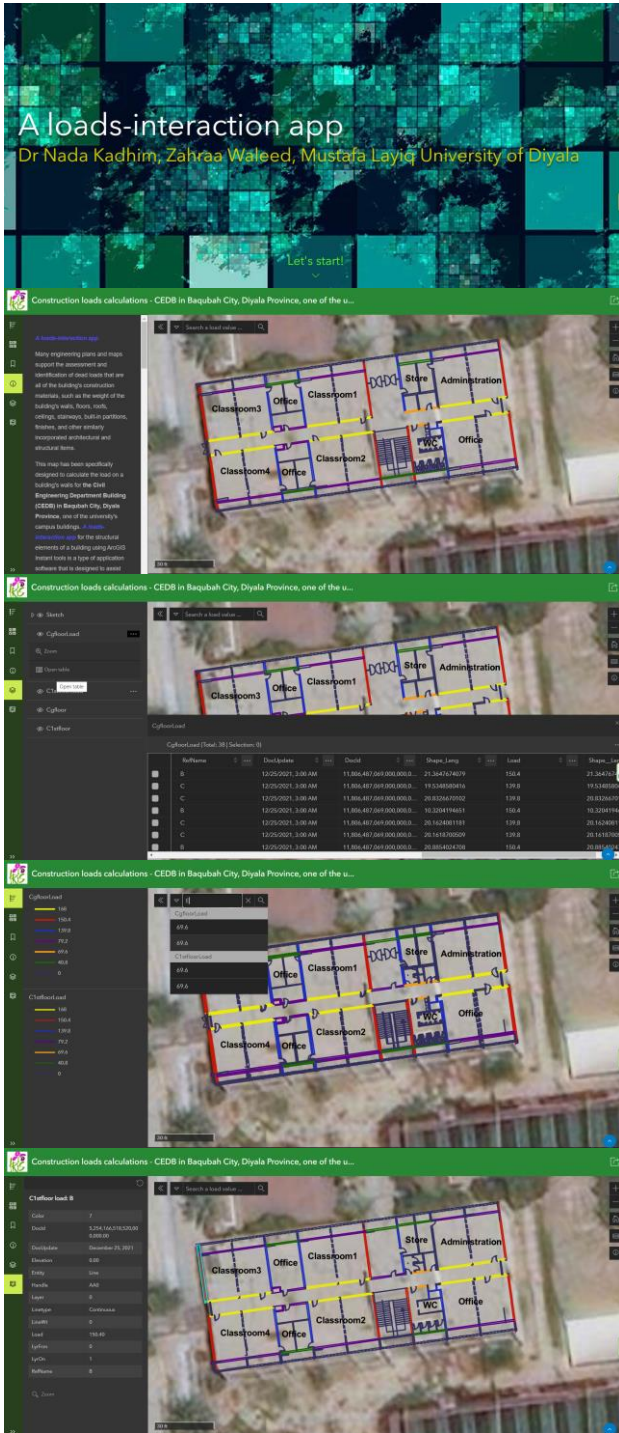


**Figure 5.** The classification of load-bearing walls of the selected building comprising two floors using ArcGIS Online.

## 5. CONCLUSION

Any building that is being expanded must now urgently know its dead loads, especially if an additional storey is being considered. When going over these specified limits, safety issues raised by the overall building loads should be taken into account. If an interactive map with the wall weights and their computations is available, stakeholders and decision-makers will be able to make the best choice regarding the building's addition of another storey.

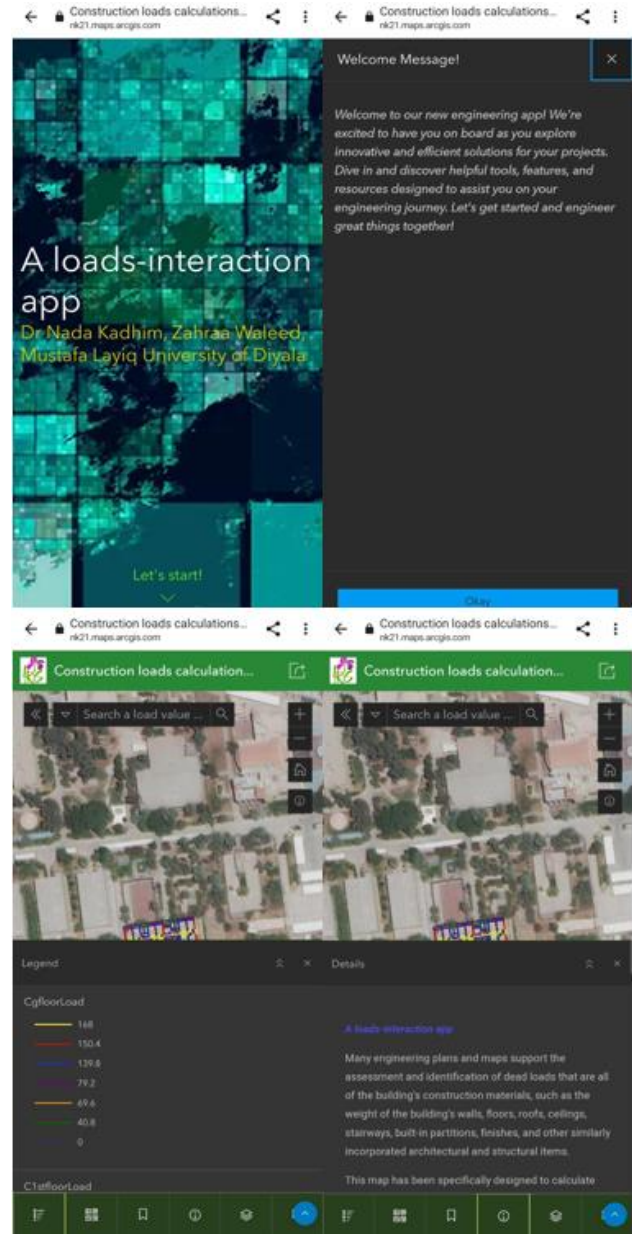
In our research, we present the creation of an outstanding application that is intended to precisely display the computations of the dead loads of the building, concentrating on its walls. With the help of this app, we were able to deploy effective technologies that can provide an interactive map of accurate estimates depending on structural criteria entered by the user, such as wall types and measurements. For engineers, architects, and other construction industry experts, the user interface was created with usability and accessibility in mind, resulting in a simple and practical experience. The purpose of this work is to increase environmental researchers' knowledge of such technologies since they might find it useful to use specialised mobile and web Apps. Such Apps could improve their data quality, accuracy, and workflow, which could lead to better results from investigations. However, there is still room for development and additional research in this field, despite the substantial progress that has already been done.



**Figure 6.** The publicly accessible loads-interaction App illustrates the intro panel and advances beyond the intro (web app).

### ACKNOWLEDGEMENTS

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**Figure 7.** The publicly accessible loads-interaction App illustrates the intro panel and advances beyond the intro (mobile app with four selected pages).

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