STABILITY ANALYSIS OF GRAVITY DAM USING MATLAB PROGRAMMING

A

PROJECT REPORT

Submitted in partial fulfillment of the requirements for the award of the degree

of

MASTER OF TECHNOLOGY

in

CIVIL ENGINEERING

With specialization in

STRUCTURAL ENGINEERING

Under the supervision

of

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(Assistant Professor)
and
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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

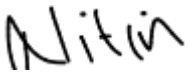
WAKNAGHAT, SOLAN – 173234

HIMACHAL PRADESH, INDIA

May 2021

STUDENT'S DECLARATION

I hereby declare that the work presented in the Project report entitled **"STABILITY ANALYSIS OF GRAVITY DAM USING MATLAB PROGRAMMING"** submitted for partial fulfillment of the requirements for the degree of Master of Technology in Civil Engineering, with specialization in Structural Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of my work carried out under the supervision **Dr. Saurav, Assistant Professor Dr. Tanmay Gupta, Assistant Professor .** This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.



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Name: Nitin kumar

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled "**STABILITY ANALYSIS OF GRAVITY DAM USING MATLAB PROGRAMMING**" in partial fulfillment of the requirements for the award of the degree of Master of Technology in Civil Engineering with specialization in "Structural Engineering" and submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Nitin Kumar (192655)** during a period from July 2020 to December 2020 under the supervision of **Dr.Saurav,Assistant Professor and Dr.Tanmay Gupta, Assistant Professor**, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

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NITIN KUMAR
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ABSTRACT

Numerous and big constructions were being conceded out. a day to cofirm bound functions. Dams area unit one amongst such constructions. they're used for the persistence of irrigation, power generation or typically merely to stock water. Numeral forces acts on dam like water force, own weight, etc. Considering all the forces and analyzing them manually is monotonous method. A gravity dam could be a solid structure, made from concrete or masonry, created across a watercourse to make a reservoir on its upstream. The section of the gravity dam is more or less triangular in form, with its apex at its high and most dimension in spite of appearance. The section is thus proportioned that it resists the varied forces working on it by its own weight. during this paper analysis of dam is dispensed victimisation Matlab software package to investigate varied forces working on the dam. The equations written reduce manual calculations and helps to calculate various forces working on dam

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

S.NO	ABBREVIATIONS	DETAIL
1.	F.S.O	factor of safety against overturning
2.	LA	Lever Arm
3.	**U**	**Uplift Pressure**
4.	J	Unit weight of concrete
5.	He	Horizontal hydrodynamic pressure

LIST OF FIGURES

LIST OF TABLE

CHAPTER 1
INTRODUCTION

1.1 GENERAL

A gravity is that the dam factory-made from stone masonry, concrete and developed to hinder water through victimisation solely the burden of the substance and its aversion against the inspiration to hinder the horizontal force of water, its base is wider than the crest, wherever wide base helps to resist overturning and slippy , gravity dams area unit terribly tangled structures and endure many varieties of forces like static and dynamic in nature, usually during this work a non-overflow dam(koyna dam) that is one among the most important dams in geographic region whose height is 103m , base breadth is 70m many forces functioning on the dam structure which include vertical, horizontal and earthquake forces that area unit manually calculated at varied points (heel & toe) and considering same dimensions on matlab wherever equations area unit being created and calculative the forces that area unit functioning on dam, these equations will be accustomed calculate forces in 2 circumstances i.e. once the reservoir is empty and once the reservoir is full.

1.2 FORCES THAT ACTS ON GRAVITY DAM

- Dam weight
- Pressure of water
- Uplift pressure
- Ice pressure
- Silt pressure
- Wave pressure
- Earthquake pressure
- Hydrodynamic pressure
- Wind pressure

1.1 Weight of the dam

The major resisting forces ar dam body itself and its foundation. the essential load is that the burden that obstructs all the external forces that acts on dam. The forces that acts downward indicates the overall dam weight boards at the c/g of the dam.

1.2 Pressure of water(P)

P is that the prime external force that acts on dam, it is assess by hydrostatic pressure diagram, the intensity is zero at high of the water surface. The pressure of water is most at the lowest and minimum at the highest.

1.3 Uplift pressure

It is the second major outside force that acts on dam owing to ooze, it happens as water oozing through the cracks Associate in Nursingd seams through dam body at the proximity surface b/w the dam and its foundation at the toe and base use in uplifts pressure at very cheap of the dam, by creating a emptying chanel in b/w dam and its foundation, and by grouting of the muse.

1.4 Ice pressure

In cold states from time to time ice might melts and expand wherever dam needs to face the inflated ice that exerts additional pressure, it action is linear beside the length of the dam. The magazine of this ice pressure ranges between250 to 1500 kn/m2 depends on things of setting, on different hand its 500kn/m2 for typical circumstances.

1.5 Silt pressure

If silt deposited at the height 'h' abutting the upstream of the dam, its exerted pressure can be elected by Rankine's formula,

Pslit = $\frac{1}{2}$ γsub h^2 Ka (acts at h/3 from base)
Where h is the height of silt deposited.
K_a is the coefficient of active earth pressure of silt = $\frac{1-sin\varphi}{1+sin\varphi}$
(φ *is the internal friction angle of soil*)

1.6 Wave pressure

Waves square measure originated on the upstream surface of reservoir by wind pressure which might produce a force towards the lower stream, wave pressure additionally rest on wave height h_w). The scoop intensity happens because of wave action could also be given as: Pw = 2.4 four however (acts at hw/2 meters higher than the stills water surface).

1.7 Earthquake Forces

Earthquake causes waves that area unit practiced of shaking the surface upon that dam is resting or positioned, the capability of earthquake is up to transmit associate motion to the muse of the dam during which the waves area unit motion to. Earthquake waves could moves in many directions and for style motive it wants resolve in 2 parts i.e. vertical and horizontal parts

1.8 Vertical Acceleration

Vertical acceleration occurs in upward or in downward. In upward direction dams foundation will be hefted upward which increase the effective weight of the damand and rise in stress developed. In downward case foundation may try to move away in downward direction from the dam body.

1.9 Horizontal Accelration (a_h)

Horizontalacceleration might reason the subsequent two forces .

1 Hydro dynamic Pressure: Horizontalacceleration stand-in near the reservoircauses a transitory surge in the water pressure, by way of the groundwork anddam hasten in the direction of the reservoir and the water struggles theeffort owing toits inertias. This process exerts a pressure which is known as hydro dynamic pressure

2 Conferring to Zanger's formula, hydrodynamic pressure is;

$Pe = Cm\ kh \cdot \gamma w$ ·H …..(1)

The resulting force due to this pressure is

$Pe = 0.726Cm\ kh \cdot \gamma w \cdot H^2$ …..(2)

Where; Cm = 0.735($\frac{\theta}{90}$ °) is the max worth of force co-efficient for a given inestimable slope, θ is in degrees, which the up stream face makes with the horizontal, kh is the portion of gravity adopted for horizontal accelration, H is the total height of the dam.

The moment of this force concerning the bottom is given as: Me = zero.412Pe · It is any such that if the upstream facet face is inclined that doesn't prolong to quite reservoir [*fr1] depth, it is takem as verticle. If slope extends to ther quite [*fr1] depth the general slope up to the complete height slope up to the complete height is taken where the slope is taken because the worth of θ within the equation higher than

1.10 Horizontal Inertia Force. In accumulation to applying the hydraulics pressure applying hydraulic pressure, the horizontal acceleration produces associate inertia forceinto the dambody into the bodyof the dam. This force is caused so as to own the body and dam foundation along jointly portion. The made force direction are going to be conflicting to the accel;ration impoarted by the earthquake since associate earthquake may imparteither impart either the upstream orthe down stream acc, we've got to elect the direction of this force force in our stability analysis of the dam structures in our stability analysis of damin such the way it producew moistest un favourable effects below the thought-about scenario. below reservoir empty scenario, earth quake forces create effects which could produce slight tension close the toes; and thence stabilityanalysis for reservoirempty case could also be administered solely on the premise the dam weight by the ignoring the earth quake forces and keeping the section free from. Conversely, forthe detailed style, these forces should be thought-about.

1.11

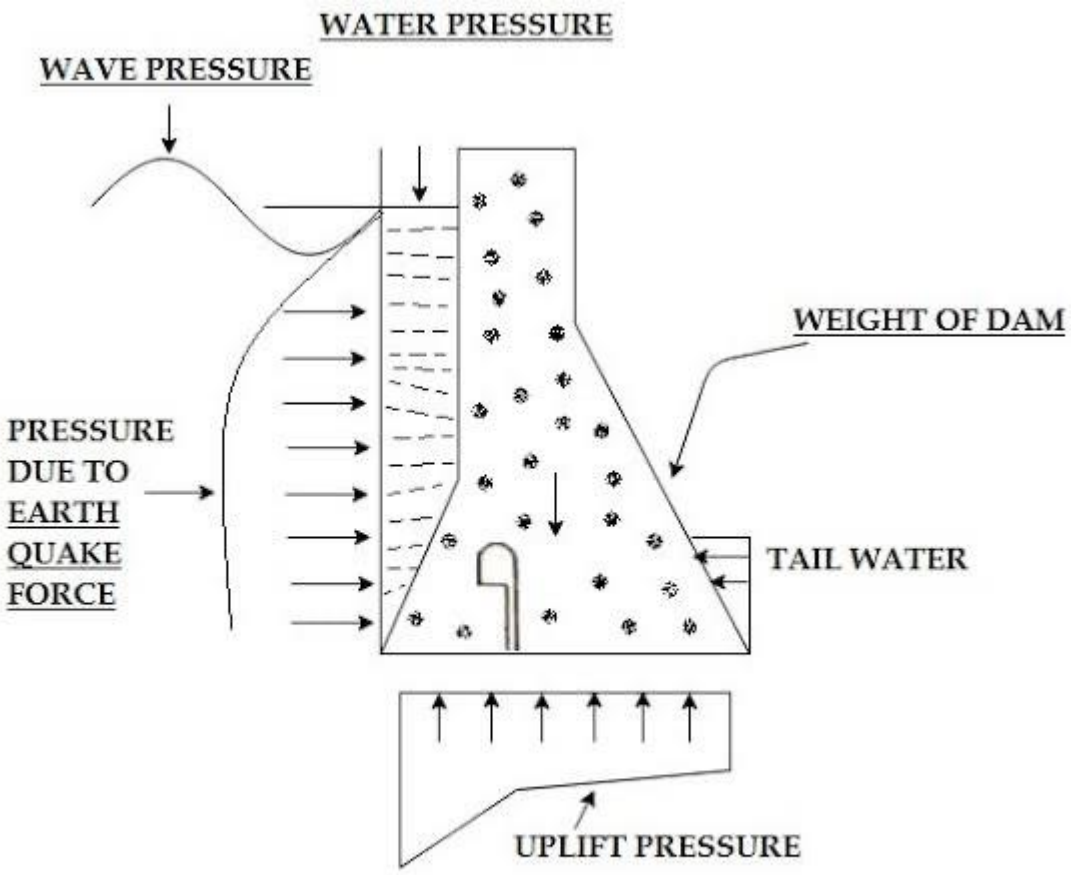


Fig.1 forces that acts on dam

1.3 Design of concrete gravity dam sections

Basically a gravity dam should fulfill the following standards:

1. It ought to be safe in contradiction of overturning on any horizontal at intervals the dam at the contact at intervals or with the inspiration.
2. The dam should be protected beside any slippy at the horizontal plane among the dam,at the exposure with the inspiration or on any geographics.

The particular phase should be in proportion such the suitable stresses in each the concrete and therefore the foundation mustn't surpass. Protection of the dam structure is to be inspected against conceivable loading, the classification is completed interms of quality and forthe proportional implication ofthe laod. Crucial masses square measure recognized as universally applicable and of major crucial of the load.

1. Key loads are recognized as invariably application & of major implication of the load.

2. Subordinate load are usually voluntary and oflesser amount like sedimentlaods or thermalstresses due to the mass concreting.
3. uncommon masses square measure maped out on the muse of forced common relevance or taking low probabilities of incidence like mechanical phenomenon masses connected with unstable activity. Technically a concrete gravity dam its constancy from the forces of gravity of the material with in the sections and thus an equivalent. The gravity dam has acceptable weights therefore on hold out against the forces and therefore the overturning moment by the water applicable within the reservoir behindit..it shifts shiftsthe hundreds tothe muse by cantilever exploit so sensible foundations square measure requirement for the gravitydam.

1.4 The forces which gives stability ti the dam includes:

1. Dam weight
2. Plunge of the tail water

1.5 The forces try to weaken the dam include:

1. pressure of water in reservoir
2. Upliftpressure
3. Forces due to the waves
4. Pressure due to ice
5. Temperature stresses
6. Siltpressure
7. Seismicforce
8. Windpressure

1.6 The forces to be repelled by the gravity dam:

1. Forces like dam weight and pressure of water that square measure calculated directly from the unit weight of material and fluid pressure proprerties.
2. Forces like uplift, ice pressure earthquake hundreds, pressure of silt and that square measure supposed solely on the premise of supposition of various reliableness degree. in reality to access this force class, superior care ought to be taken and dependency sited on accessible information, expertise and discernment.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

IIT Kharagpur(2010), broadly categorized dams according to construction materials. The categorization is as follows:

1. Embankment dams - These are dams constructed of natural material scraped or procured from the proximity of a dam site.

2. Earth-filled dams - For constructing the majority of the dam this dam uses compressed soil. it's created basically by selecting out engineering soils targeted compressed orderly and effectively in skinny layers at a managed wetness content. This dam could also be similar wherever only 1 style of soil is out there and also the dam height is low or could also be outlined wherever over one style of soil material is employed. they're the foremost in-expensive style of dam and makes use of materials, sometimes accessible domestically, that don't need a high degree of process. However, thee dams ar very exposed to erosion and need consistent taking care of. Also, soil mercantilism could also be essential if the soils within the space or not clay soils.

3. Concrete dams - Use of mass concrete in dams made started because of simplicity of construction and to match tough to grasp styles, like having a wasteweir inside a dam body. Mass concrete will be created stronger by the utilization of additives like scum, pulverised fuel ash so as to cut back temperature activated issues or to steer away from undesirable cracking and total value of the project.

2.2 Types of concrete dams include:

1. **Arch dams –** These kinds of dams have important quantity of upstream curvature Associate in Nursingd have confidence an arched action on the bridge ends through that of the water masses is passed onto the walls of the stream vale.

2. **Buttress dams –** These types of dams comprise of an uninterrupted upstream face backed up at regular intermittently by buttress walls and the downstream side.

3. Gravity dams - A gravity dam is the one which rely upon completely on its own weight for balance and support. It might be manufactures of masonry or concrete of masonry or of concrete.

2.3 Other classifications of dams include

1. **Based on function and use**

   Storage dams (or conservation) dams: These square measure dams ready-made to remain surplus flood water throughout the season where there is a massive flow at intervals the watercourse to be build use of later throughout the quantity once there is ablated at intervals the flow of watercourse flow at intervals the watercourse. The water unbroken at intervals the waterbody formed at intervals the upstream is utilized for a numeral of motives, like facility, hydropower and irrigation

2. **Diversion dam**: A diversion dam is factory-made for the explanation for resurrect the extent of water and direct watercourse water into an off-taking canal (or a conduit) or a conveyance system wherever it should be used as run-off watercourse electricity theme, irrigation or water system.

3. Hydraulic design:

(i) **Overflow dams**: An over flow dam is originated to act as associate degree overflow structure. the excess water that can't be preserved within the waterbody is permissible to travel higher than the crest of the overflow dam that turns as a wasteweir. The overflow dam is created of a substance like masonry cement concrete or masonry that doesn't erode/scour by the overflowing water action.

(ii) **Non-overflow dams**: a non-overflow dam is meant in order that there's no flow higher than it. Surplus water isn't permissible to flow over the highest of the dam and a dissimilar conduit far from the body of the dam is given to throw out the excess flood water.

4. Scope And Objectives

Here a two dimensional stability analysis of the dam that square measure having most height of 103 meter is finished first by victimization the gravity of procedure of study that could be a balanced analysis methodology. severalforces acts on the body of dam that has horizontal and vertical earthquake forces square measure discovered and conjointly the stresses square measure studied manually at dissimilar points, i.e. at toe and heel. the strain found over every techniques is tabulated and square measure connected for the accuracy of manual calculation. Dam foundation reservoir crossing is abandoned and conjointly the dam is probable to be. Dam foundation reservoir intersection is abandoned and conjointly the dam is foretold to be mounted at the lowest. Inertia forces evoke thanks to acc caoused by earth quake, and these accelerations square measure thought-about fraction of PEAK GROUND ACCELRATION(PGA)and square measure place into the dam. The material is supposed to be elastic, isotropic. The worstthings for earthquake forces square measure thought-about and a couple of case i.e.empty reservoier and full reservoir things square measure supposed of.

5. Gravity Method Stability Analysis

The initial examination of gravity dams are going to be done simply by separating a typical crosswise of the dam. This division is supposed to perform individually of the connecting section. where in different words, the dam is contemplated to be made up of form of cantilevers of unit dimension each, that act individually of each different. this opportunity of freelance functioning of each section takes no notice of the action of beam inside the dam. If the vertical sloping joints of the dam do not appear to be stuffed or inputted on, this supposition is closely true. therefore for wide formed valleys, where transverse joints do not appear to be ultimately stuffed, this supposition is type of contented . but simply just in case of slender fashioned valleys where transverse joints unit of measurement sometimes inputted and so the full span of the dam monolithically as associate exclusive body, this supposition could embody sizable mistakes. In such cases, initial vogue are often done by gravity technique and unequivocal final vogue are often permissible out by three dimensional ways. the soundness analysis of a dam section is accepted resolute check the safety and security with relevance.

- Rotation and overturning
- Translational and sliding
- Overstress and material failure

6. Gravity method is based on beam theory and is applicable if the following suppositions are satisfied:

- The dam is gave the impression to be created from sort of cantilevers, each of that's 1m thick and every of that acts autonomous of the opposite.
- Noloads are moved to the abutments by beamaction.
- The foundation and therefore the dam behavesas one unit i.e., the joint existence glorious.
- The materials within the foundation and dam body area unit undiversified and isotropous Stresses developed in the foundation and dam body are within elastic limits.
- No motion of the foundations iscaused in line for to conversion load.

- Little apertures created at intervals the body of the dam do not have an impact on the common distribution of stresses which they entirely turn out restricted outcome.

7. **Westergaard(1933)-** Presented an manoeuvre to see regarding the linear response of the dam-reservoir theme by variety of plenty that area unit another to the dam body. The method, that is usually applied in second analysis, treats the dam as a firm structure on a firm foundation and assumes that the fluid mechanics result on a rigid dam is admire the mechanical phenomenon force succeeding from a mass circulation another on the dam body.

8. **Chopra, A.K. (1980)-** Offered a simplified analysis technique for dynamic study of concrete gravity which contain merely the basic vibration means in scheming the look forces. In his study, the gravity dam is taken into account as two-dimensional finite part system, the reservoir as AN infinite zero in the upstream direction with constant depth, and therefore the foundation as a finite part system. This simplified technique may be fittingly employed in preliminary style of huge gravity dams or within the final style of little dams. during this technique the interface effects between the versatile dam and reservoir are concerned, however dam foundation interfaces are unnoticed.

9. **Leclerc et. al. (2002)-** the main varieties and association of CADAM, a laptop package that has been established for the static and seismal stability estimations of concrete gravity dams. CADAM relies on the gravity methodology mistreatment rigid body symmetry and beam system to execute stress analysis, reckon crack lengths, and safety factors.

10. **IS 1893-1984-**

Conditions for earthquake impervious design of structures, recommends the subsequent techniques for the purpose of earthquake forces on concrete gravity dams;

- Seismic coefficient method (for the dams to 100m ht)
- Response spectrum method(for dams of height larger than100m)

2.4 MODELING

The stability of the dam can be examined in the various steps:

- Observe unite dam lenght
- Workout the enormousness &direction of the all vertical forces acting on the sam andtheir alg sum i.e. ∑V.
- Likewise workout all thehorizontal and there alg sum i.e. ∑H
- Calculate the leverarm of all the forces about the toe.
- Calculate the moment of all marines almost the toes and findout the alg sum of all those moments sum of all those moments, i.e. ∑M
- Obtain the location of the resultant force by determining its distance from the toe. X = ∑M/∑V
- Obtain the eccentricity (e) of the resultant by e = B/2-X

It must be less than B/6 in order to make sure that there is no tension is developed anywhere in the dam.

- Determine the minimum and maximum normal stresses at heel and toe

$Pmax\ /min = \sum V/B\ (1 \pm 6e/B)$ ……(3)

- Define the max normal stresses i.e. principle stresses at the heel using

$\sigma attoe = Pvsec2 \propto -(P' - Pe')\ tan\ 2 \propto$ …….(4)

- Where, Pv is that the intensity of traditional pressure at base of the dam, P' is theintensity of pressure on the downstream face exerted by tail water, Pe' is that the hydraulics pressure exerted by tail water throughout associate degree earthquake moving towards reservoir.

  $\propto$ is the angle made by downstream face and vertical

  $\sigma atheel = Pv \cdot sec\ 2\varphi - P' + Pe'\ tan\ 2(14)\ \tau = (Pv - P') \propto$ ….(5)

- Where, φ is the angle made by upstream face and vertical (They should not out do maximum allowable values).

- Determine the safety factor against overturning.

F.S. O = $\sum MR/ Mo$

$\sum MR$ is the summation of stabilizing moment and $\sum Mo$ is the summation of overturning moment.

The factor of safety against overturning (F.S.O.) usually varies from 1.5 to 2.

- Define the F.S against sliding, using sliding factor as:

S.F.F. = $\mu \sum V/\sum$

- Define the F.S against Sliding, using sliding factor as:

S.F.F. = $\mu \sum V/\sum$

Where, $\mu\sum$V is that the shear confrontation and $\sum$V is that the total verticalforce; μ is that the continual of friction between the incentive and dam, that varies from zero.65-0.75; and which can differs from zero.65 - 0.75; and $\sum V$ is that the all over external horizontal forces in low dam a, the security against slippery should be checked for friction solely, however in high gravity dams, for efficient precise styles, the joint shear strength, that is Associate in Nursing supplementary shear resistance, should even be inspected. If this shear confrontation of the joint is scrutinised, then the eq of for issueof safety agains slippery that is decorous by shear friction issue (S.F.F.) become: S.F.F. = ($\sum$V+Bq)/ $\sum H$ wherever, letter is that the avg shear strength of the joint which can varies from regarding 1400 KN/m2 for poor rocks to regarding 4000 KN/m2 perpetually rocks.

2.5 For the stability analysis using gravity method two cases are considered

- Reservoir empty case
- Reservoir full case

2.6 Material use:-

Young's modulus	31027 Mpa
Poisson's ratio	0.15
Density	25.5 KN/m3
Compressive initial yield stress	13 Mpa
Compressive ultimate stress	24.1 Mpa
Tensile failure stress	2.9 Mpa

2.7 Reservoir Empty: Case 1

In empty reservoir, the many forces acting workedout area unit in Table a pair of with mention to Fig. 2. Horizontal earthquake forces acting towards upstream area unit thought of. Stability is examined for 2 sub-cases i.e.

- When the vertical earthquake forces are additive to the dam weight.
- When vertical earthquake force is subtractive to the dam weight.
- (A worth of zero.1g to 0.15g is often ample for the high dams in unstable zone for horizontal unstable constant (Garg2013). we tend to assume a worth of zero.1g as horizontal and zero.05g for vertical unstable coefficients severally.)

2.8 Reservoir Full: Case 2

Horizontal earthquake stirring within the direction of the reservoir manufacturing upstream acceleration and making horizontal inertia forces within the direction of downstream is taken into account because it is that the worst case for this example. Also, a vertical earthquake stirring downward and generating forces upward, i.e., subtractive to the dam weight is examined. Full uplift pressure is inspected. it's supposed that there's no tail water within the downstream face. Fig. two shows the many forces working on the dam during this circumstance. Magnitude and moment of those forces regarding the toe ar listed in Table three. alphabetic character is that the hydraulics pressure, its magnitude and moment caused by it's calculated from Zanger's formula.

- According to Zanger's formula

- hydrodynamic pressure is; **(**$Pe = Cm\ kh \cdot \gamma w \cdot H$) ……(7)

- Resultant force due to this pressure is
  $P_e = 0.726 C_m\ k_h\ \gamma_w\ H^{\ 2}$…..(8)

- Where; C_m= zero.735(θ/ ninety °) is that the most price of pressure co-efficient for a given constant slope, θ is that the angle in degrees, wherever the upstream face makes with the horizontal is that the angle in degrees, that the upstream face makes with the horizontal, kh is that the fraction of gravity adopted for horizontal acceleration, H is that the total height of the dam.
- $P_e = 0.735 \times 0.1 \times 9.81 \times 91.75 = 66.15\ KN/m2$ …(9)

- $P_E = 0.726 \times 66.15 \times 91.75 = 4406.3 KN$ …(10)

- $M_e = 0.412 Pe.H$…..(11)

- $M_e = 0.412 \times 4406.3 \times 91.75 = 166562.54\ KN.\text{m}$ …..(12)

2.9 Koyna Dam

Which is one among the biggest dams in geographical region whose height is 103m, base dimension is 70m , many forces performing on the dam structure that encompass vertical, horizontal and earthquake forces that square measure manually calculated at varied points (heel & toe) and considering same dimensions on Matlab wherever equations square measure being created and calculative the forces that square measure performing on dam, these equations will be wont to calculate forces in 2 cases

- When the reservoir if empty
- When the reservoir is full

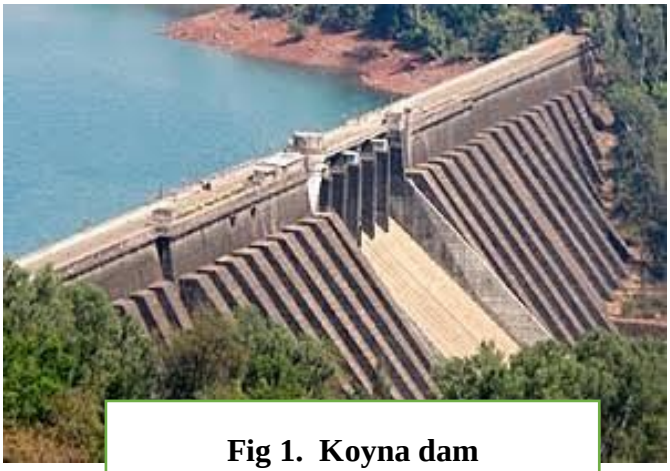
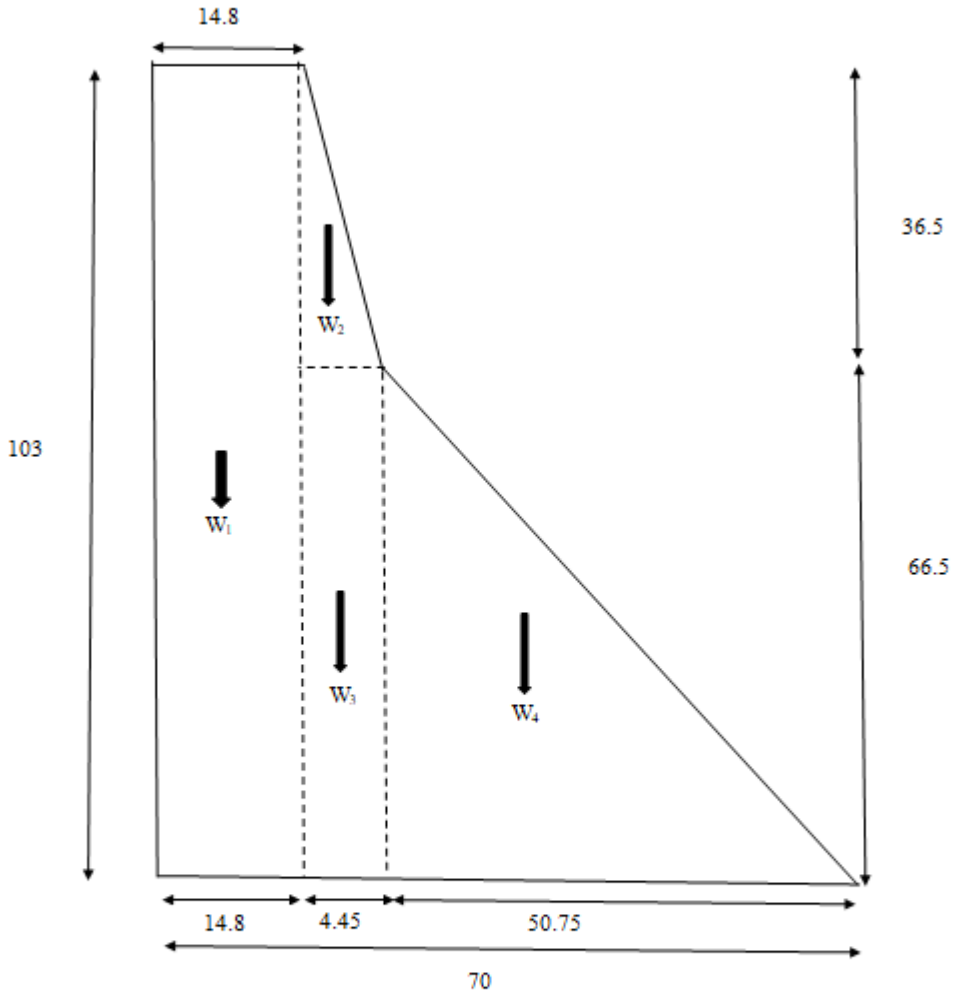


Fig 1. Koyna dam

2.9.1 Fig 2: Reservoir empty condition (dimensions in meter)



2.9.2TABLE-2: Forces acting on dam in reservoir empty case:

Name of force	design ation	Magnitude of Force(KN)		Leverarm about toe(m)	Moment about toe anticlockwise(+)in(KN-m
		Verticalforces(KN) (+)↓ (-)↑	Horizontal forces toward u/s(+ve)		
Wt of the dam	W_1	(+) 14.8x103x25.5 =38872	----------	62.6	+2433387
	W_2	(+)$\frac{1}{2}$x4.45x36.5x2525=2071	----------	53.7	+111213
	W_3	(+)66.5x4.45x25.5= 7546	----------	53.9	+399183
	W_4	(+)$\frac{1}{2}$x50.75x66.5x25.5 =43030	----------	33.8	+1454414
		$\sum V_1$=91519	----------		$\sum M_1$=4398196
vertical earthquake forces		$\sum V_2$=0.05$\sum V_1$ =0.05x91519 =4576			$\sum M_2$ =0.05$\sum M_1$ =0.05x4398196 =219910
		Note: For vertical earthquake forces and moments corresponding to them no sign is considered a they are considered to be acting as two cases i.e. downward and upward.			
Horizontal earthquake forces	0.1W_1		=0.1x38872=3887	51.5	-200180
	0.1W_2		=0.1x2071=207	78.66	-16283
	0.1W_3		0.1x75546=755	33.25	-25104
	0.1W_4		0.1x43030=4303	22.16	-95354
			$\sum$H=9154		$\sum M_3$= -336921

2.9.3Table3- Forces acting on the dam in reservoir full case

Name of force	designation	Magnitude of Force(KN)		Lever arm about toe(m)	Moment about toe anticlockwise(+)in(KN-m)
		Vertical forces(KN) (+)↓ (-)↑	Horizontal forces toward u/s(+Ve)		
Wt. of the dam	W_1	(+) 14.8x103x25.5 =38872	----------	62.6	+2433387
	W_2	(+)$\frac{1}{2}$x4.45x36.5x2525= 2071	----------	53.7	+111213
	W_3	(+)66.5x4.45x25.5= 7546	----------	53.9	+399183
	W_4	(+)$\frac{1}{2}$x50.75x66.5x25.5 =43030	----------	33.8	+1454414
		$\sum V_1$=91519	----------		$\sum M_1$=4398196
Upward vertical earthquake forces		$\sum V_2$=0.05$\sum V_1$ =0.05x91519 =4576			$\sum M_2$ =0.05$\sum M_1$ =0.05x4398196 =219910
Horizontal earthquake forces	0.1W_1	----------	=0.1x38872=3887	51.5	-200180
	0.1W_2	----------	=0.1x2071=207	78.66	-16283
	0.1W_3	----------	0.1x75546=755	33.25	-25104
	0.1W_4	----------	0.1x43030=4303	22.16	-95354
			$\sum H$=9154		$\sum M_3$=-336921
Uplift pressure	U	$\frac{1}{2}$x900x70=-31500		46.7	$\sum M_4$=-1471050
Horizontal hydrodynamic pressure	P_e=	----------	Calculated separately earlier		
			=(-)4406.3 $\sum H_2$=-4406.3		$\sum M_5$=-166562.54
Hydro static pressure	P	----------	$\frac{1}{2}$x900x91.75=41287.5 $\sum H_2$=-41287.5	30.6	-1263397.5 $\sum M_6$=-1263397.5

2.5.6-Table 4: Stress results for reservoir empty case (Mpa)

Empty Reservoir and vertical earthquake acting upward			
Manual results		**Matlab results**	
Tension at heel	tension at toe	Tension at heel	Tension at toe
$2.769x10^3$	155.02	$2.755x10^3$	-140.48
Empty Reservoir and vertical earthquake acting upward			
Manual results		**Matlab results**	
Stress at heel	Stress at toe	Stress at heel	Stress at toe
0	255	0	-230

Reservoir Full condition			
Manual results		Matlab results	
Stress at heel	Stress at toe	Stress at heel	Stress at toe
1.94	-0.36	1.73	-0.007

CHAPTER 3

METHODOLOGY: MATLAB

3.1 INTRODUCTION:

Matlab is a special purpose programming language and it is stands for Matrix Laboratory, it is a superior tenacity computer sequencer raised to execute engineering and scientific calculations. It ongoing as a platform design to achieve matrix mathematic but progressively it has grown to a flexible computing method which is capable of solving fundamentally any practical problem, Matlab is referred as a high level language because as compared to assembly level language which is also known as low level programming languages like C and C++, matlab offers a very powerful and sophisticated package. In this part, the study of numerical modeling is carried out by using the software Matlab. The objective of this study is to examine the conduct of the gravity dam.

- Matlab is a software design level taken into consideration particularly for engineers and scientists. The middle of Matlab is the Matlab language, a matrix-primarily based totally language allowing the finest herbal look of computational mathematics. Using Matlab we are able to examine files, data, domesticate algorithms, make fashions and applications.The language, apps, and in-constructed math capabilities assist you to unexpectedly discover numerous tactics to reach at a solution.

- Matlab charges you proceeds your opinions from exploration to creating with the aid of using deploying to business enterprise programs and entrenched devices.

- Matlab could be a software system for doing statistical working out. It became at first intended for fixing algebra compassionate problems the occupation of matrices. It's judgment springs from MATrix LABoratory.

- Matlab has afterward remained dilated and presently has in-constructed tenacities for locating troubles wanting records analysis, sign process, improvement, and more than a few of different|and numerous different} different forms of medical computations. It conjointly includes features for 2-D and 3D pix and animation.

- The **command window** is where you'll give Matlab its input and view its output.

- The **workspace** shows you all of your current working variables and other objects.

- The **history** shows you all commands you used in command window.

- The Publishing supervisor for Matlab scripts (M-files) . to save lots of & run the m-file press 'F5' and to uncluttered the corrector with a brand new or previous m-file use the command open file_name

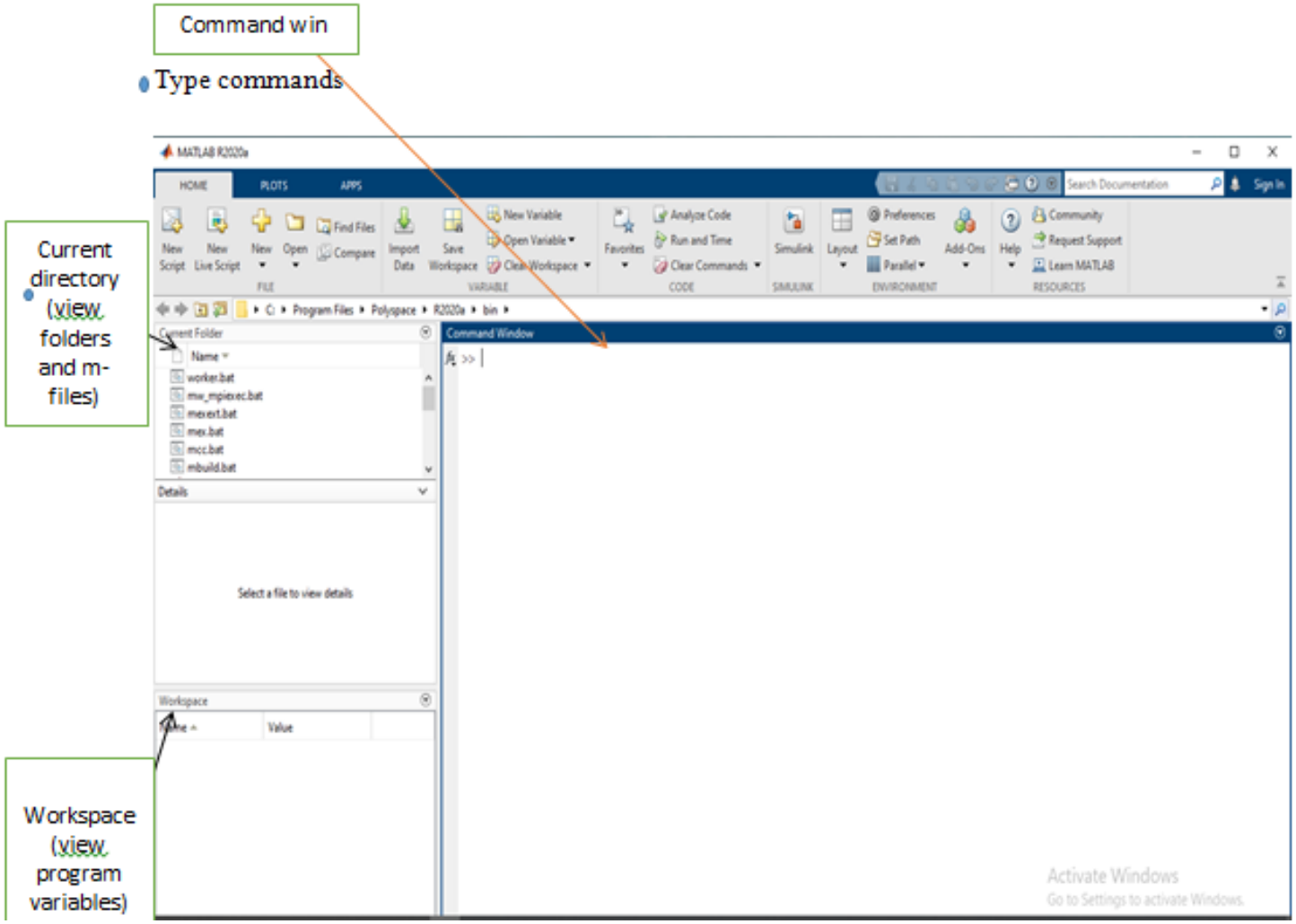
3.2ADVANTAGES OF MATLAB

- Matlab syndicates the modeling visualization and computation in user friendly way.
- For matlab aseparate matlab complier presented,this is the compiler which can assemble a matlab software package to a true executables code that runs more rapidly than any interpreted code.
- Matlab derives with the all-encompassing archive of pre defined functions and makes it easy for programmer.
- Matlab provide independent platform.

3.3MATLAB APPLICATIONS

- It assist to get real time simulation and report compeers.
- Analysis of measurement and test can be done.
- Matlab finds extensive applications Artificial intelligence, machine learning and Data Analytics.

3.4MATLAB ENVIROMENT



3.5 PRE DEFINED FUNCTIONS

FUNCTION NAME	PURPOSE
Inv(A)	Inverse of matrix A
det(A)	Determinate of matrix A
rank(A)	Rank of a matrix A
Disp(A)	Display matrix A
Sort(A)	Sorts elements of matrix in ascending order
Min(A)	Returns min of A
Max(A)	Returns max of A

3.2 MATLAB HELP

For help, command description etc use F1 or following commands:

- help *command_name*
- helpwin *command_name*
- doc *command_name*
- helpdesk *command_name*
- demo *command_name*
- lookfor *keyword* (search unknown command)

3.3 Some Useful commands.

- **What- List all m-files in current directory**
- **dir/ls- List all files in current directory**
- **type test- Display test.m in command window**
- **delete test- Delete test.m**
- **cd/chdir- Change directory**
- **pwd- Show current directory**
- **which test- Display directory path to 'closest' test.m**
- **who- List known variables**
- **whos- List known variables plus their size**
- **clear-Clear variables from workspace**
- **clc- Clear the command window**

3.4 MATLAB & Matrices

- MATLAB treats all variables as matrices. For our purposes a matrix can be thought of as an array, in fact, that is how it is stored.
- Vectors are special forms of matrices and contain only one row OR one column.
- Scalars are matrices with only one row AND one column.

3.5 Variable Names

- Variable names ARE case sensitive
- Variable names can contain up to 63 characters (as of MATLAB 6.5 and newer). One can use namelengthmax command to verify it.
- Variable names must start with a letter followed by letters, digits, and underscores.
- MATLAB variables are defined by assignment. There is no need to declare in advance the variables that we want to use or their type.

Example

- x=1; % Define the scalar variable x
- y=[1 2 3] % row vector
- z=[1;2;3] % column vector
- A=[1 2 3;4 5 6;7 8 9] % 3x3 matrix
- whose % List of the variables defined
- Note: terminate statement with semicolon (;) to suppress output.

3.6 Special Variables

ans	Default variable name for results
pi	Value of π
eps	Smallest incremental number
inf	Infinity
NaN	Not a number e.g. 0/0
i,j,1i,1j	imaginary unit *i*, i.e. square root of -1
realmin	The smallest usable positive real number
realmax	The largest usable positive real number

3.7 Other symbols

>>	prompt
. . .	continue statement on next line
,	separate statements and data
%	start comment which ends at end of line
;	(1) suppress output
	(2) used as a row separator in a matrix
:	specify range

3.8 Relational Operators

MATLAB supports six relational operators.

Less Than	<
Less Than or Equal	<=
Greater Than	>
Greater Than or Equal	>=
Equal To	==
Not Equal To	~=

3.9 Math & Assignment Operators

Power	^	or	.^	a^b	or	a.^b
Multiplication	*	or	.*	a*b	or	a.*b
Division	/	or	./	a/b	or	a./b
or	\	or	.\	b\a	or	b.\a

NOTE: 56/8 = 8\56

- (unary) + (unary)		
Addition	+	a + b
Subtraction	-	a - b
Assignment	=	a = b (assign b to a)

3.10 MATLAB Logical Operators

MATLAB supports five logical operators.

not/~	element wise/scalar logical NOT
and/&	element wise logical AND
or/ |	element wise logical OR
&&	logical (short-circuit) AND
||	logical (short-circuit) AND

3.11 Logical Functions

MATLAB also supports some logical functions.

xor (a, b)	exclusive or
any(x)	returns 1 if any element of x is nonzero
all(x)	returns 1 if all elements of x are nonzero
isnan(x)	returns 1 at each NaN in x
isinf(x)	returns 1 at each infinity in x
finite(x)	returns 1 at each finite value in x
find(x)	find indices and values of nonzero elements

3.12 M-Files

An M-file might be used as a script, i.e. file consist set of statements
In additional, one use M-files to write function, in this case the file starts with function definition like:

Function y = f(x)
Function [u,y] = f(x,y,z)

File name and the name of function in the file are usually identical, however while they are different, MATLAB use file name to call function.
If you add additional function in same M-file, it considered sub-function and might be called from inside the M-file only. Only the first function might be called from outside.

3.13 Saving Results

We can save all our results for future reference .

The command

Diary 'FileName'

Saves all output to command window into the FileName.txt file until this option is Turned off by the command

Diary off

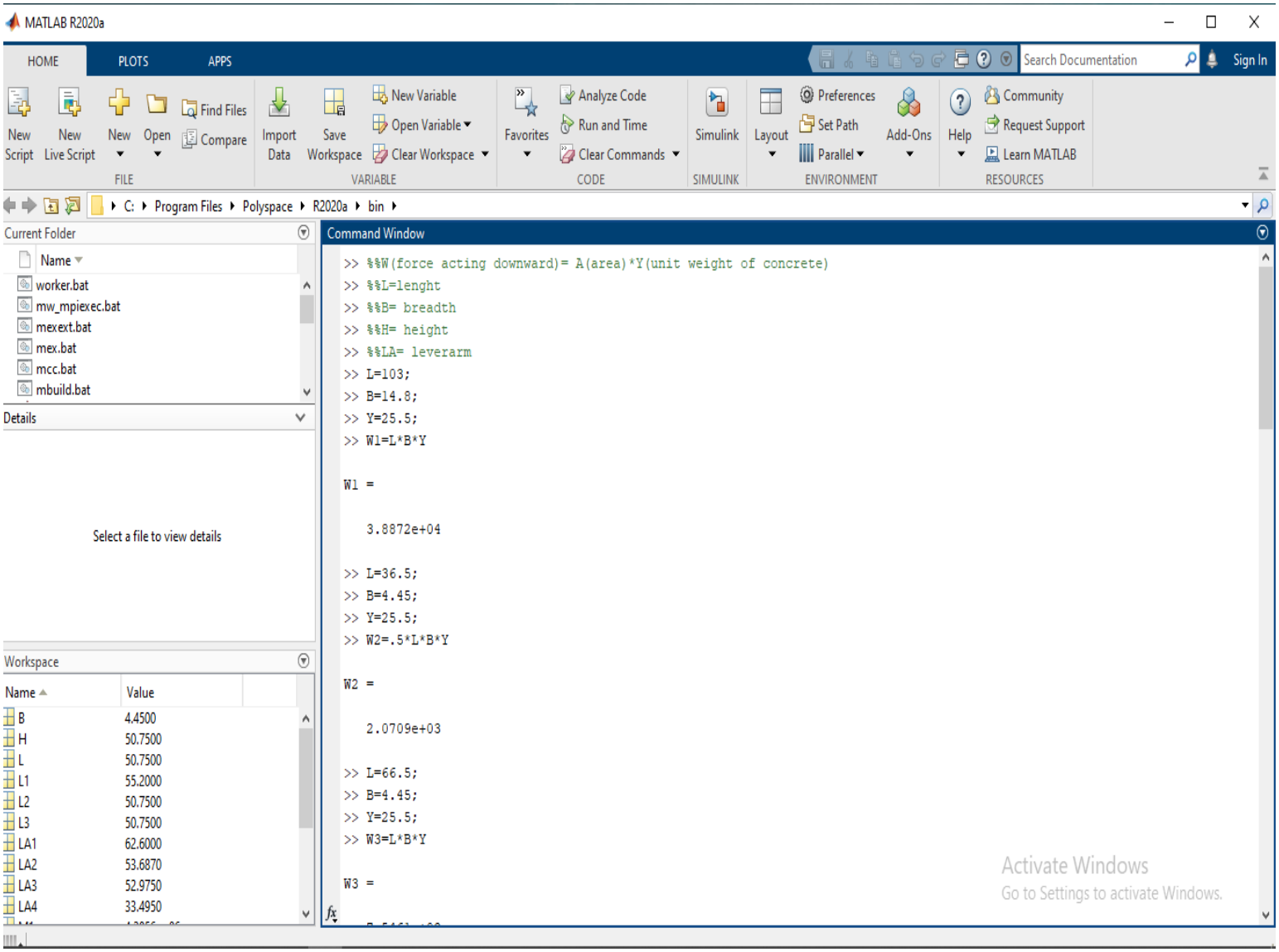
The following commands save & load the entire workspace into the file MyMatFile.mat'

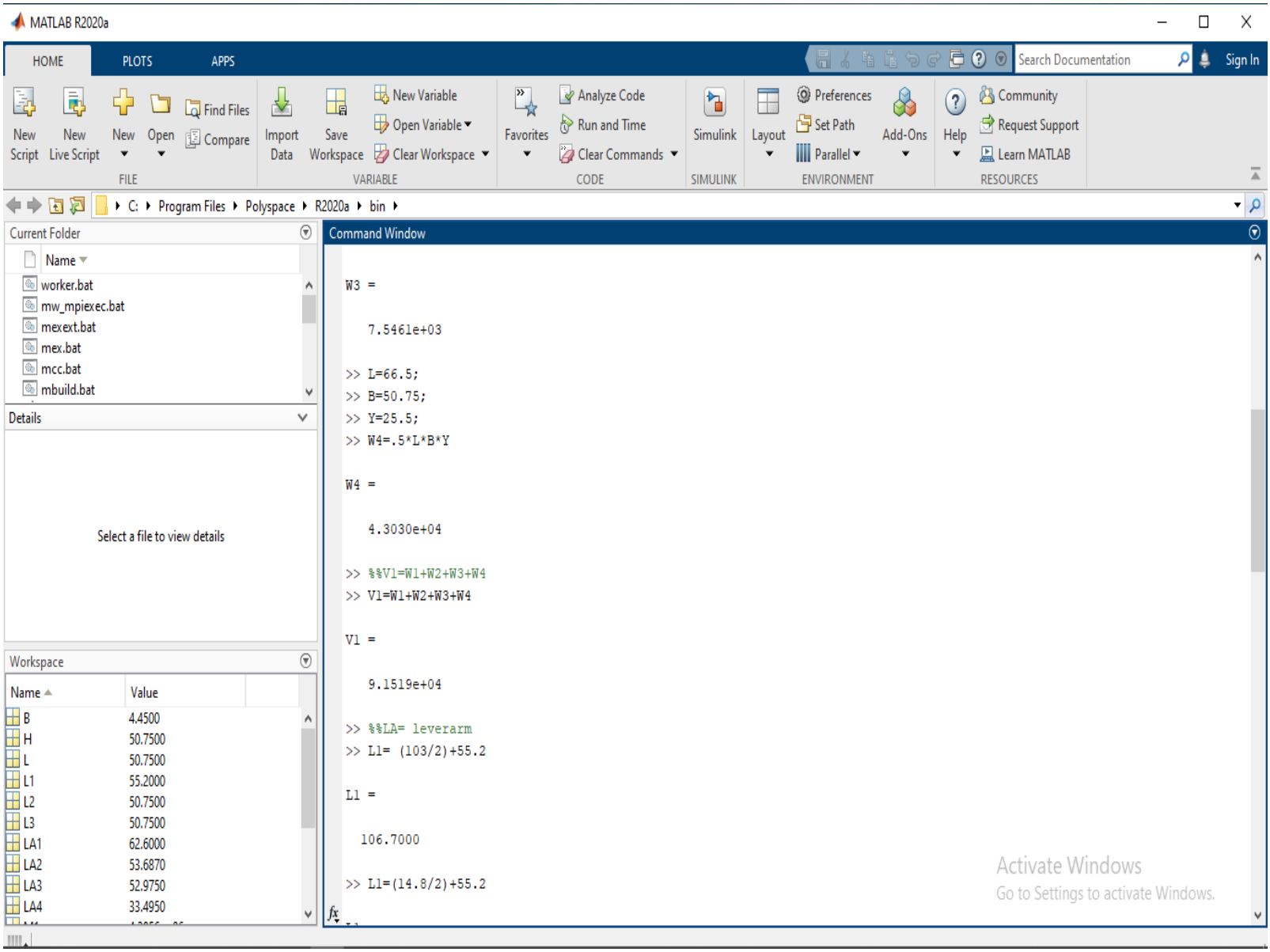
```
save 'MyMatFile'
load 'MyMatFile'
save 'x.mat' x  % save a specific variable
```

saving in ASCII format:

```
x = (-1:0.4:1)' ; y = sin(x*pi)
var = [x y]        % double-column
save 'my_sin.dat' -ASCII -double var  %Save in 16-digit ASCII format
```

3.14 Calculation of forces using Matlab

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mex.bat
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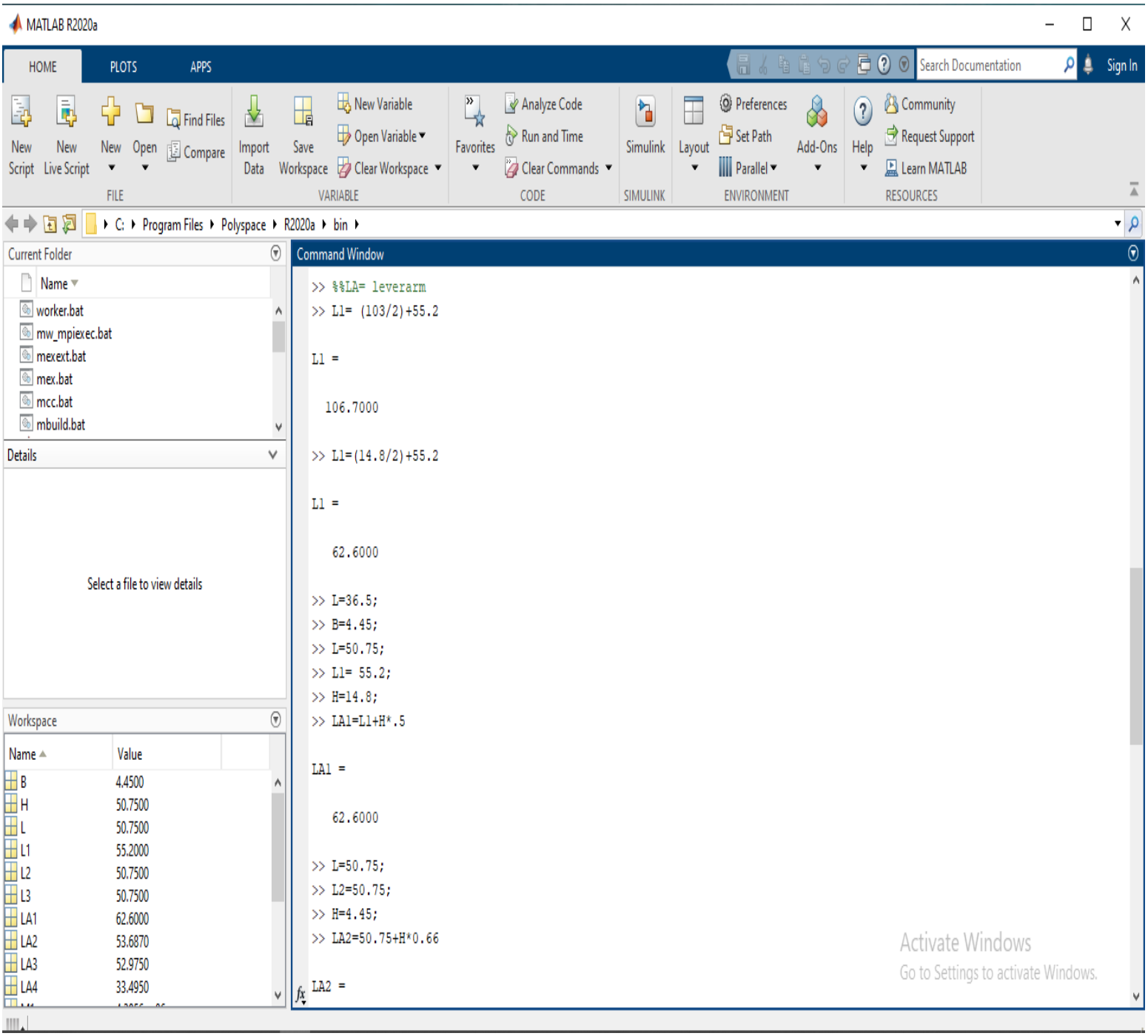
mbuild.bat
Details
Select a file to view details
Workspace
Name
Value
B 4.4500
H 50.7500
L 50.7500
L1 55.2000
L2 50.7500
L3 50.7500
LA1 62.6000
LA2 53.6870
LA3 52.9750
LA4 33.4950
Command Window
W3 =
7.5461e+03
>> L=66.5;
>> B=50.75;
>> Y=25.5;
>> W4=.5*L*B*Y
W4 =
4.3030e+04
>> %%V1=W1+W2+W3+W4
>> V1=W1+W2+W3+W4
V1 =
9.1519e+04
>> %%LA= leverarm
>> L1= (103/2)+55.2
L1 =
106.7000
>> L1=(14.8/2)+55.2
Activate Windows
Go to Settings to activate Windows.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Value
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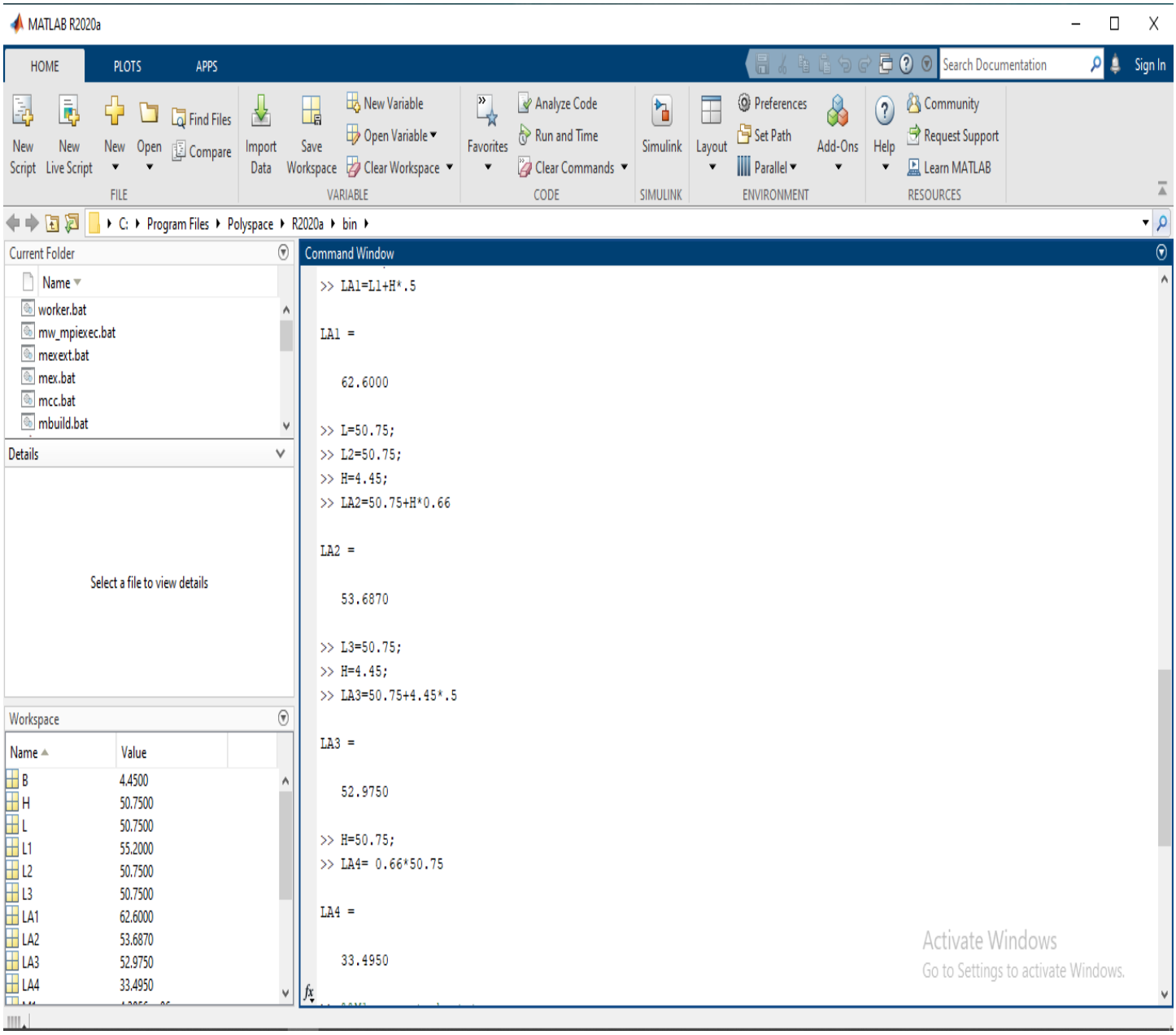
H 50.7500
L 50.7500
L1 55.2000
L2 50.7500
L3 50.7500
LA1 62.6000
LA2 53.6870
LA3 52.9750
LA4 33.4950
Command Window
>> %%LA= leverarm
>> L1= (103/2)+55.2
L1 =
106.7000
>> L1=(14.8/2)+55.2
L1 =
62.6000
>> L=36.5;
>> B=4.45;
>> L=50.75;
>> L1= 55.2;
>> H=14.8;
>> LA1=L1+H*.5
LA1 =
62.6000
>> L=50.75;
>> L2=50.75;
>> H=4.45;
>> LA2=50.75+H*0.66
LA2 =
Activate Windows
Go to Settings to activate Windows.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Workspace
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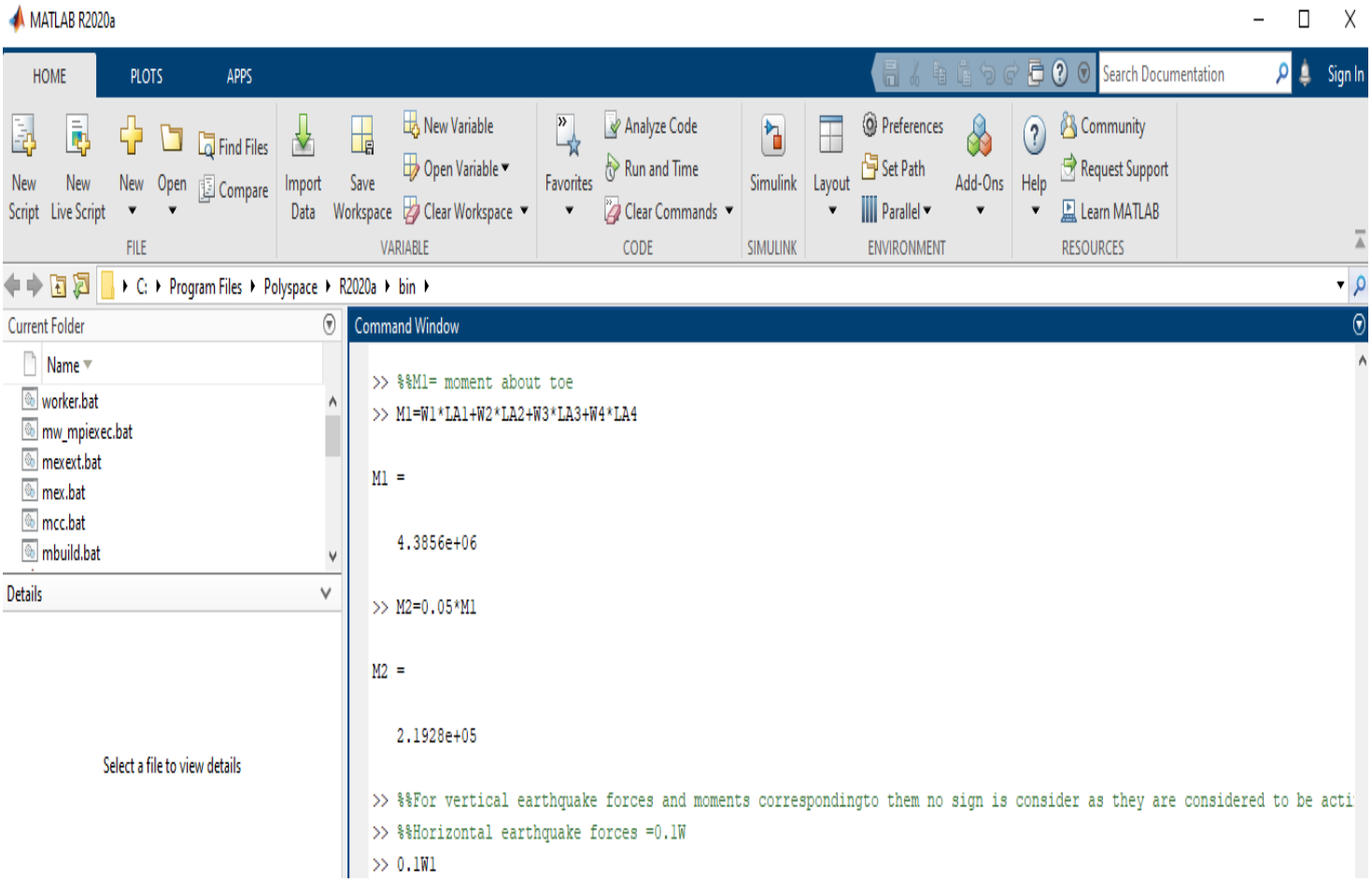
Value
B 4.4500
H 50.7500
L 50.7500
L1 55.2000
L2 50.7500
L3 50.7500
LA1 62.6000
LA2 53.6870
LA3 52.9750
LA4 33.4950
Command Window
>> LA1=L1+H*.5
LA1 =
62.6000
>> L=50.75;
>> L2=50.75;
>> H=4.45;
>> LA2=50.75+H*0.66
LA2 =
53.6870
>> L3=50.75;
>> H=4.45;
>> LA3=50.75+4.45*.5
LA3 =
52.9750
>> H=50.75;
>> LA4= 0.66*50.75
LA4 =
33.4950
Activate Windows
Go to Settings to activate Windows.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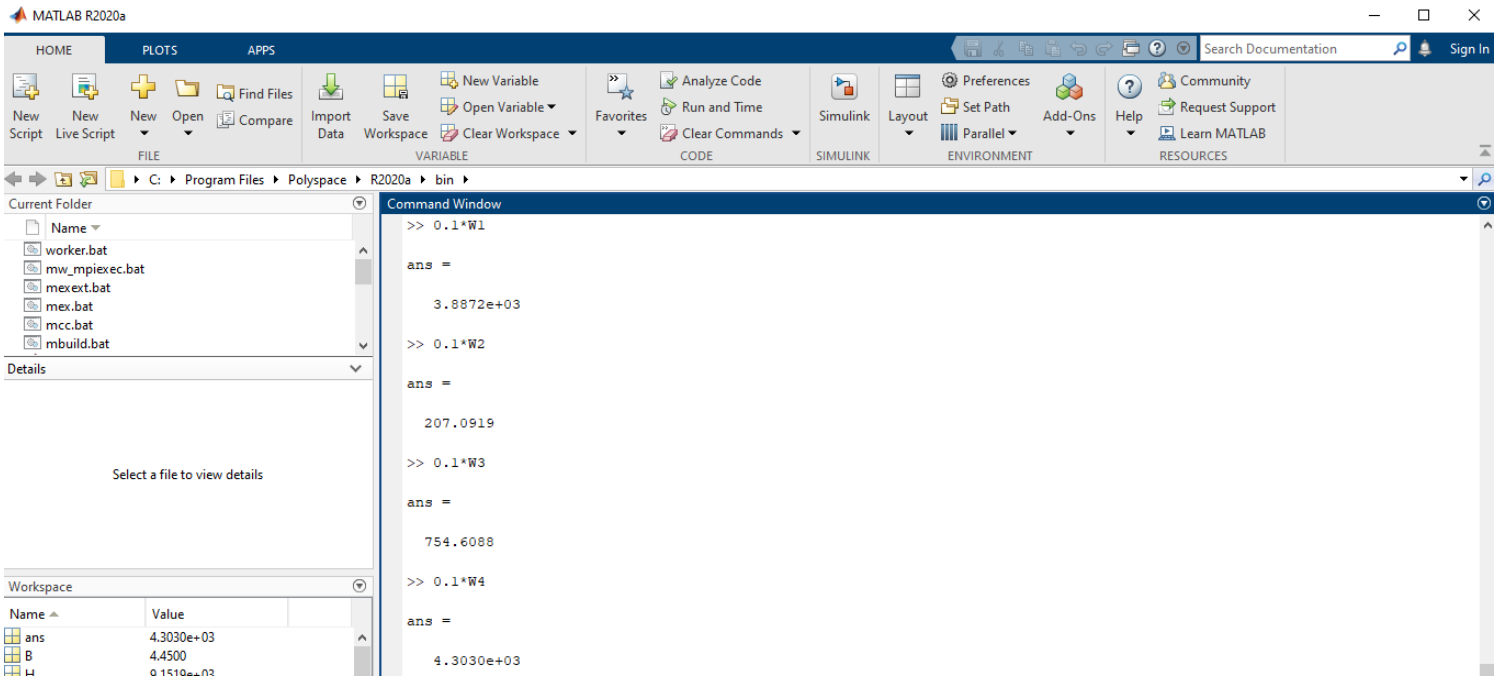
Details
Select a file to view details
Command Window
>> %%M1= moment about toe
>> M1=W1*LA1+W2*LA2+W3*LA3+W4*LA4
M1 =
4.3856e+06
>> M2=0.05*M1
M2 =
2.1928e+05
>> %%For vertical earthquake forces and moments correspondingto them no sign is consider as they are considered to be acti
>> %%Horizontal earthquake forces =0.1W
>> 0.1W1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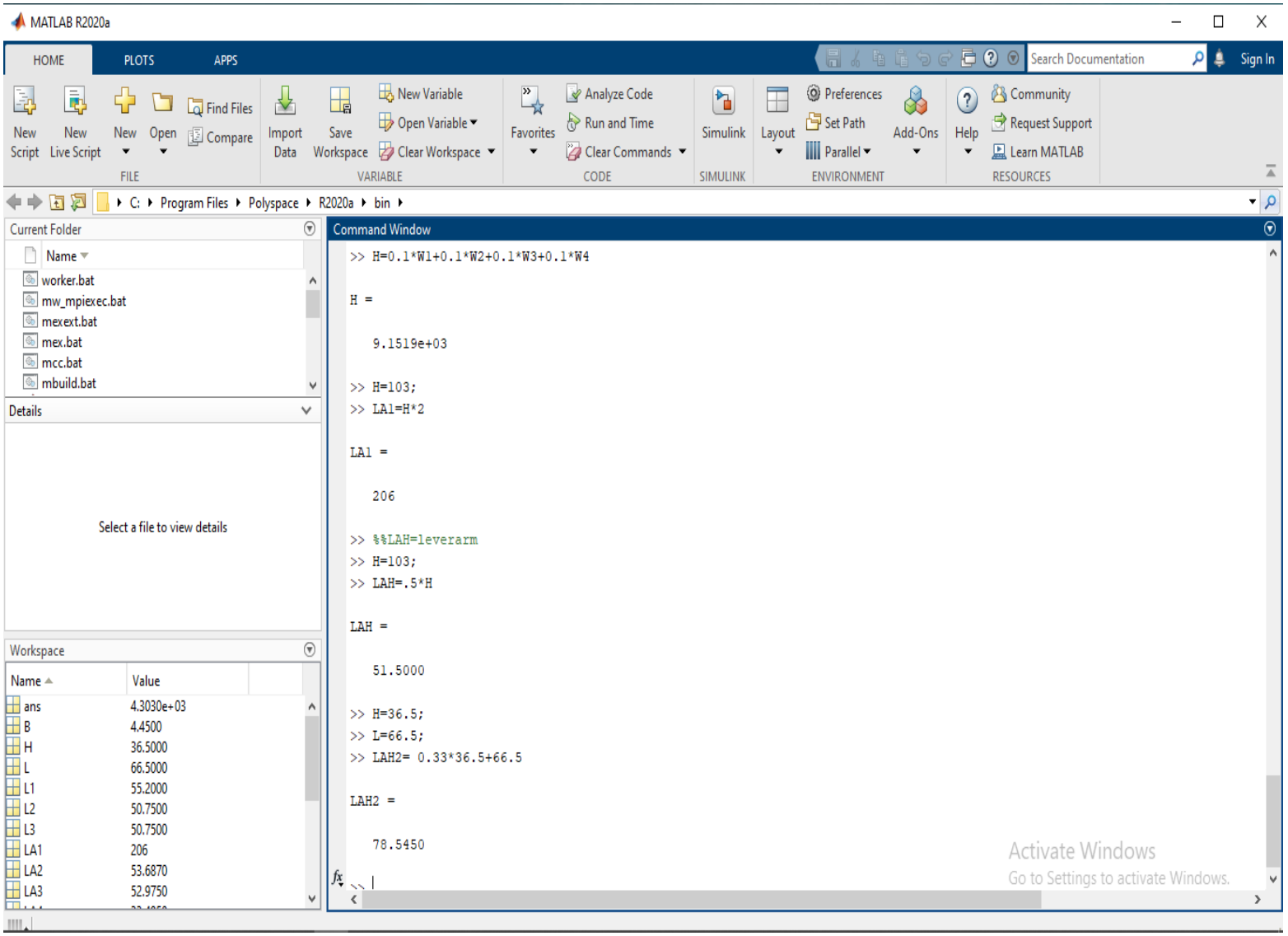
Details
Select a file to view details
Workspace
Name
Value
ans
4.3030e+03
B
4.4500
Command Window
>> 0.1*W1
ans =
3.8872e+03
>> 0.1*W2
ans =
207.0919
>> 0.1*W3
ans =
754.6088
>> 0.1*W4
ans =
4.3030e+03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Details
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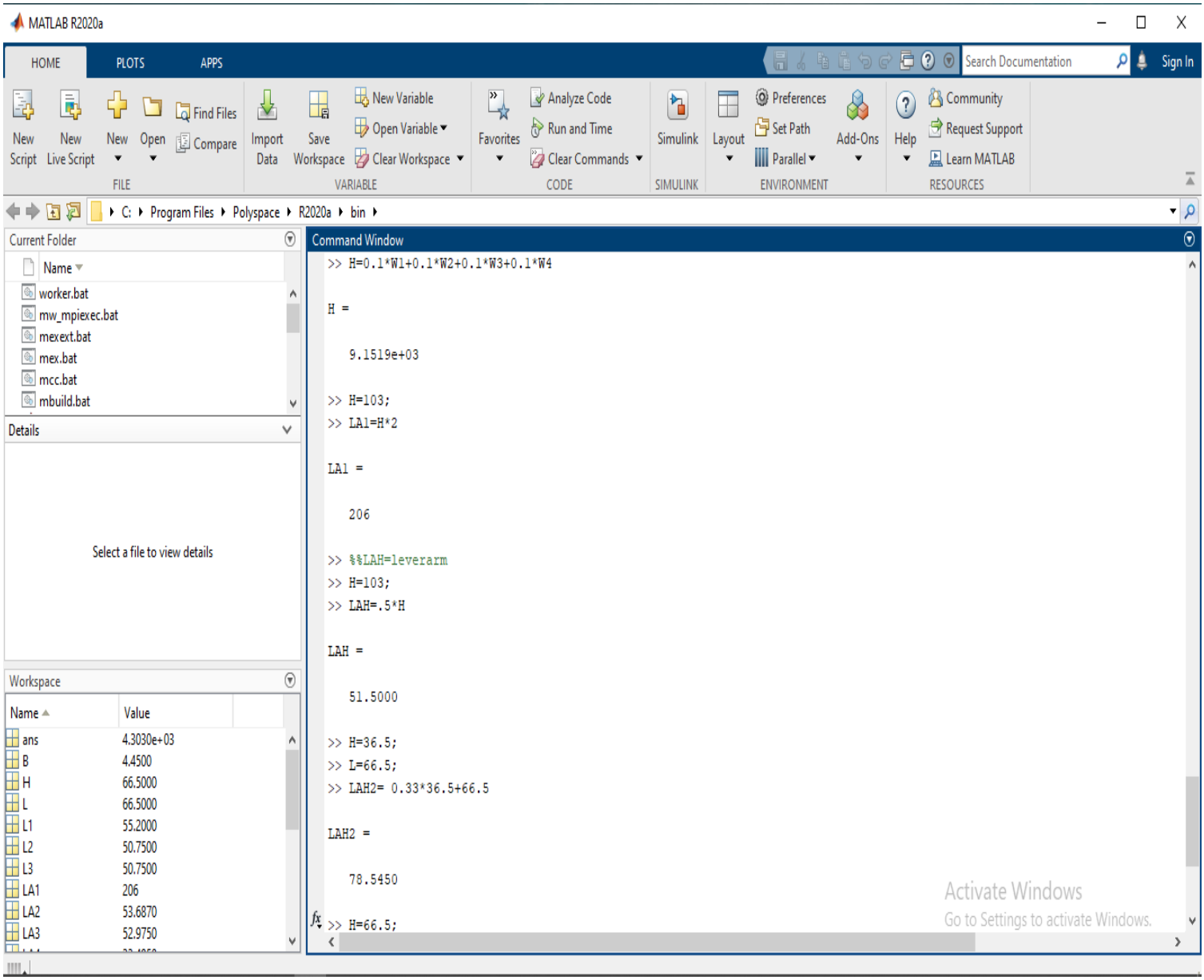
Workspace
Name
Value
ans 4.3030e+03
B 4.4500
H 36.5000
L 66.5000
L1 55.2000
L2 50.7500
L3 50.7500
LA1 206
LA2 53.6870
LA3 52.9750
Command Window
>> H=0.1*W1+0.1*W2+0.1*W3+0.1*W4
H =
9.1519e+03
>> H=103;
>> LA1=H*2
LA1 =
206
>> %%LAH=leverarm
>> H=103;
>> LAH=.5*H
LAH =
51.5000
>> H=36.5;
>> L=66.5;
>> LAH2= 0.33*36.5+66.5
LAH2 =
78.5450
>>
Activate Windows
Go to Settings to activate Windows.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Clear Workspace
Favorites
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Run and Time
Clear Commands
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Layout
Preferences
Set Path
Parallel
Add-Ons
Help
Community
Request Support
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ans 4.3030e+03
B 4.4500
H 66.5000
L 66.5000
L1 55.2000
L2 50.7500
L3 50.7500
LA1 206
LA2 53.6870
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Command Window
>> H=0.1*W1+0.1*W2+0.1*W3+0.1*W4
H =
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LA1 =
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>> %%LAH=leverarm
>> H=103;
>> LAH=.5*H
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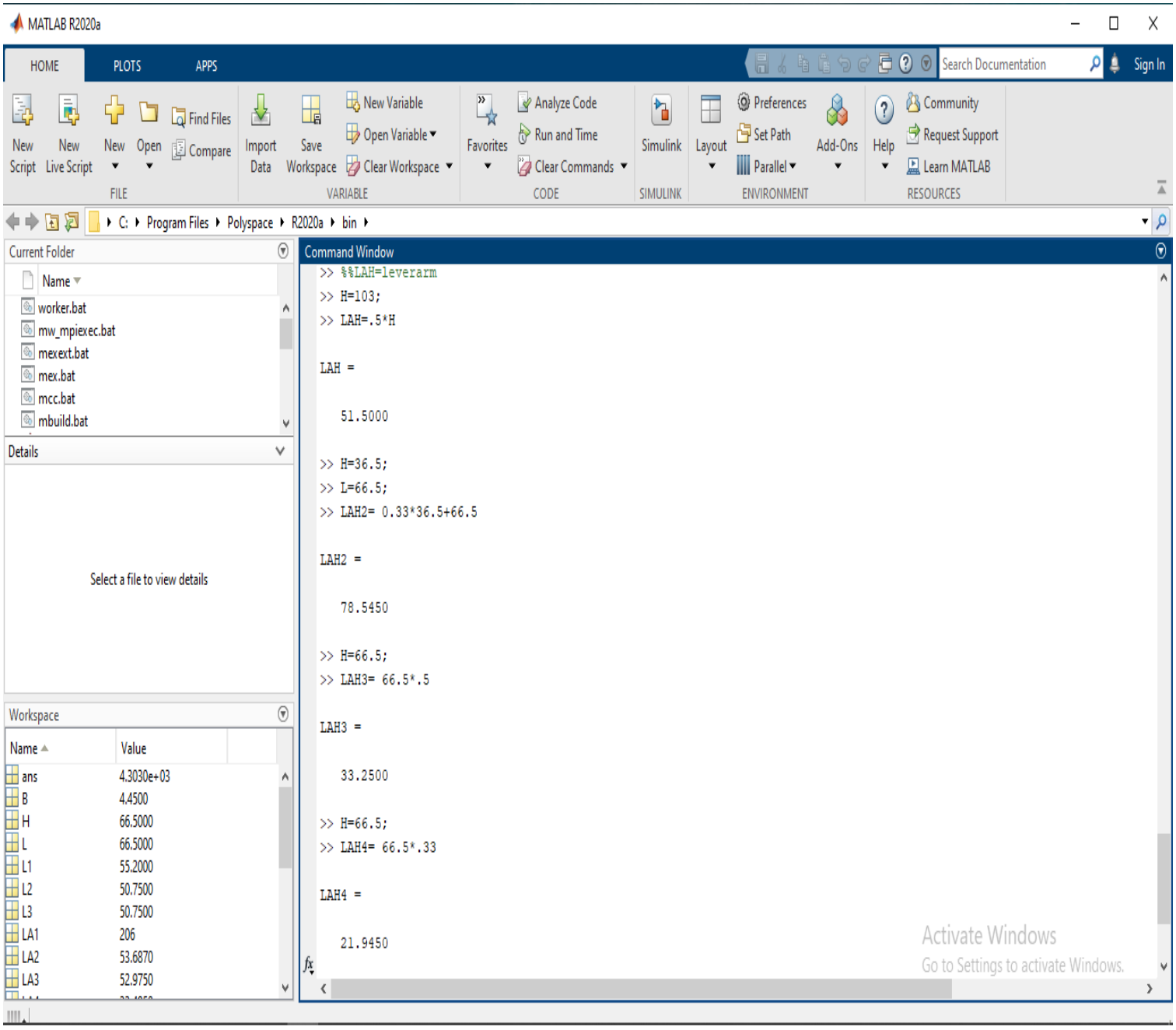
>> L=66.5;
>> LAH2= 0.33*36.5+66.5
LAH2 =
78.5450
>> H=66.5;
Activate Windows
Go to Settings to activate Windows.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APPS
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Clear Workspace
Favorites
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Run and Time
Clear Commands
Simulink
Layout
Preferences
Set Path
Parallel
Add-Ons
Help
Community
Request Support
Learn MATLAB
FILE
VARIABLE
CODE
SIMULINK
ENVIRONMENT
RESOURCES
C: ▸ Program Files ▸ Polyspace ▸ R2020a ▸ bin ▸
Current Folder
Name
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mw_mpiexec.bat
mexext.bat
mex.bat
mcc.bat
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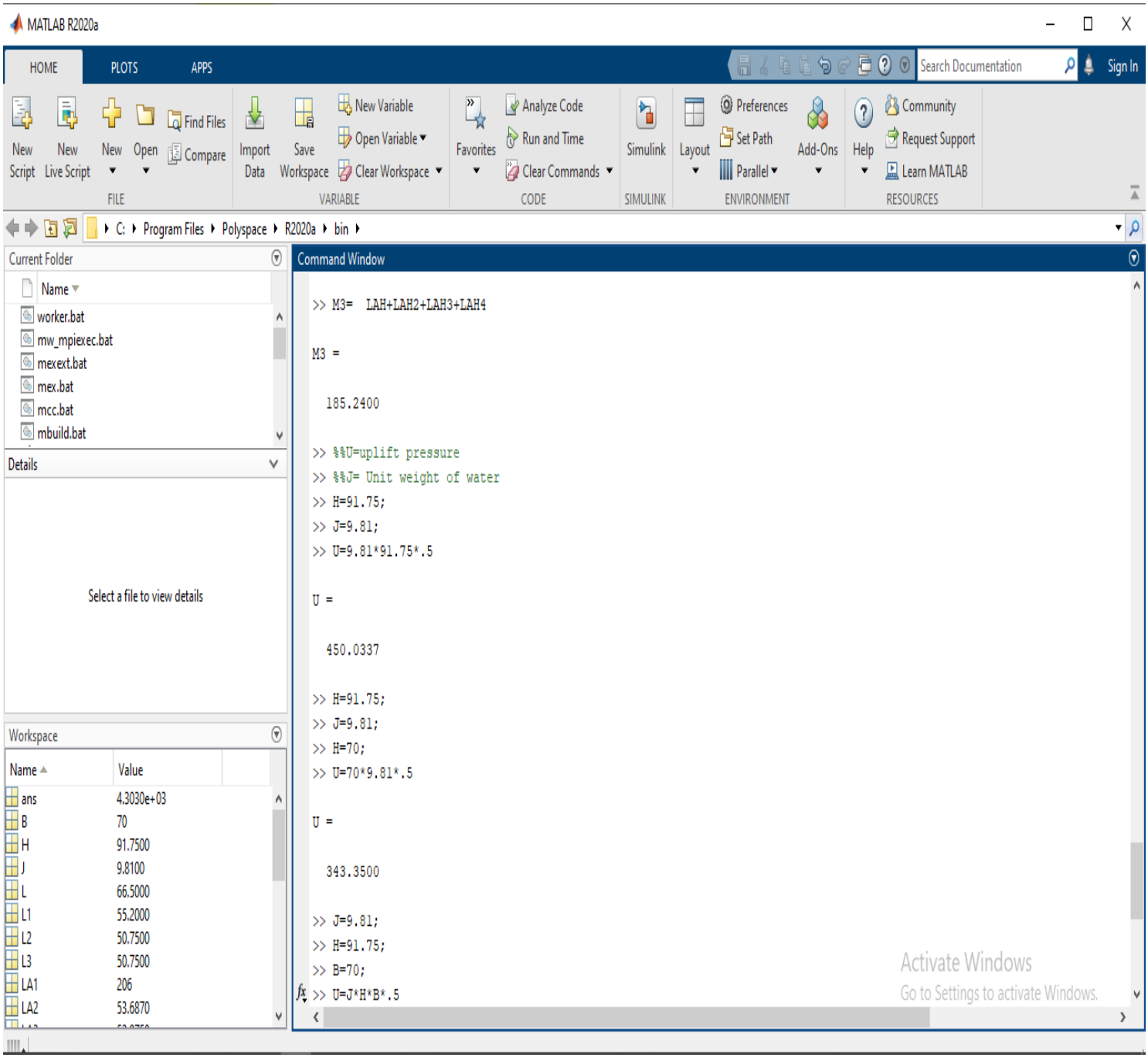
Details
Select a file to view details
Workspace
Name
Value
ans 4.3030e+03
B 4.4500
H 66.5000
L 66.5000
L1 55.2000
L2 50.7500
L3 50.7500
LA1 206
LA2 53.6870
LA3 52.9750
Command Window
>> %%LAH=leverarm
>> H=103;
>> LAH=.5*H
LAH =
51.5000
>> H=36.5;
>> L=66.5;
>> LAH2= 0.33*36.5+66.5
LAH2 =
78.5450
>> H=66.5;
>> LAH3= 66.5*.5
LAH3 =
33.2500
>> H=66.5;
>> LAH4= 66.5*.33
LAH4 =
21.9450
Activate Windows
Go to Settings to activate Windows.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Simulink
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Set Path
Parallel
Add-Ons
Help
Community
Request Support
Learn MATLAB
FILE
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SIMULINK
ENVIRONMENT
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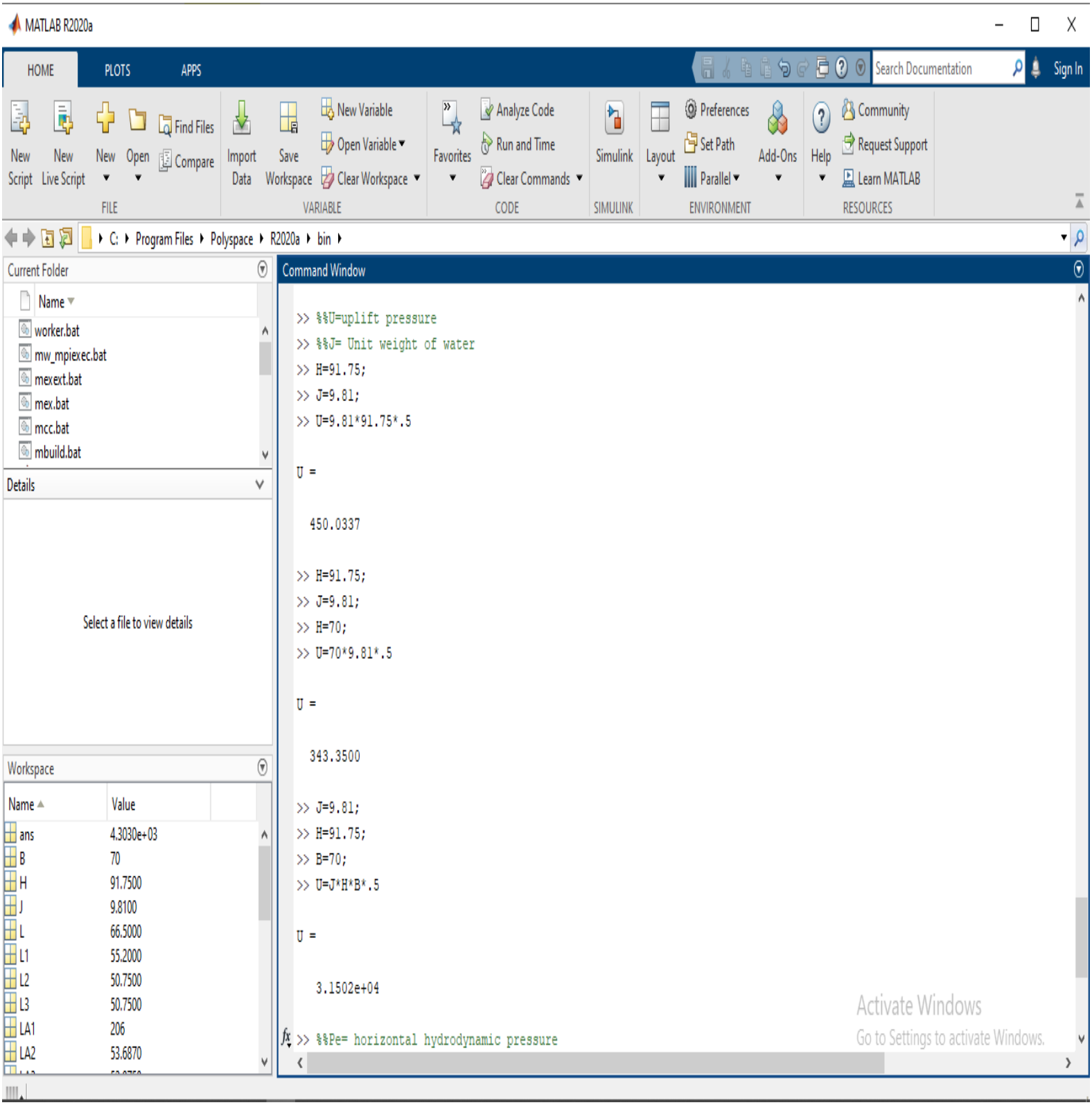
Current Folder
Name
worker.bat
mw_mpiexec.bat
mexext.bat
mex.bat
mcc.bat
mbuild.bat
Details
Select a file to view details
Workspace
Name
Value
ans 4.3030e+03
B 70
H 91.7500
J 9.8100
L 66.5000
L1 55.2000
L2 50.7500
L3 50.7500
LA1 206
LA2 53.6870
Command Window
>> M3= LAH+LAH2+LAH3+LAH4
M3 =
185.2400
>> %%U=uplift pressure
>> %%J= Unit weight of water
>> H=91.75;
>> J=9.81;
>> U=9.81*91.75*.5
U =
450.0337
>> H=91.75;
>> J=9.81;
>> H=70;
>> U=70*9.81*.5
U =
343.3500
>> J=9.81;
>> H=91.75;
>> B=70;
>> U=J*H*B*.5
Activate Windows
Go to Settings to activate Windows.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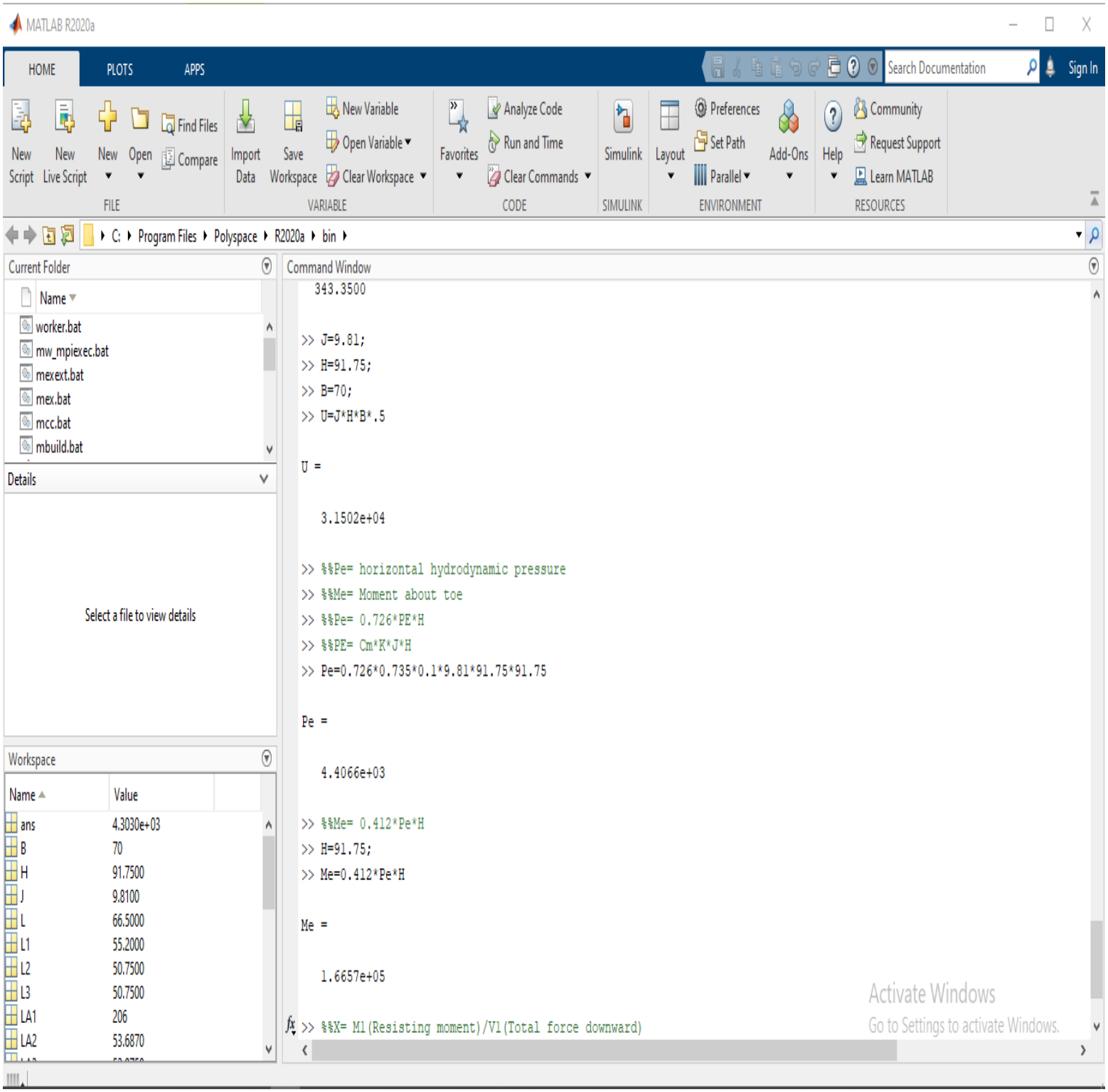
Value
ans 4.3030e+03
B 70
H 91.7500
J 9.8100
L 66.5000
L1 55.2000
L2 50.7500
L3 50.7500
LA1 206
LA2 53.6870
Command Window
>> %%U=uplift pressure
>> %%J= Unit weight of water
>> H=91.75;
>> J=9.81;
>> U=9.81*91.75*.5
U =
450.0337
>> H=91.75;
>> J=9.81;
>> H=70;
>> U=70*9.81*.5
U =
343.3500
>> J=9.81;
>> H=91.75;
>> B=70;
>> U=J*H*B*.5
U =
3.1502e+04
>> %%Pe= horizontal hydrodynamic pressure
Activate Windows
Go to Settings to activate Windows.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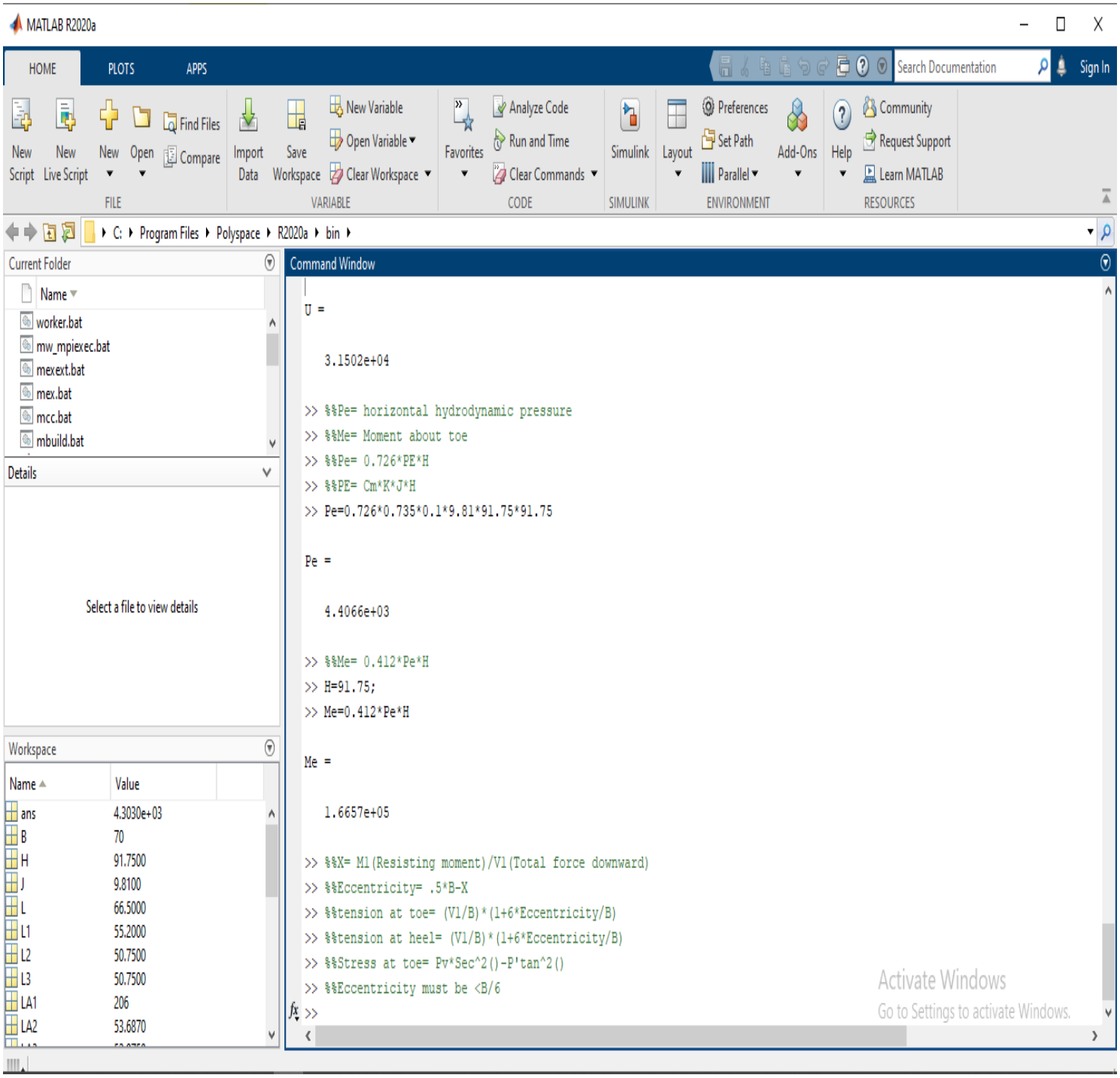
B 70
H 91.7500
J 9.8100
L 66.5000
L1 55.2000
L2 50.7500
L3 50.7500
LA1 206
LA2 53.6870
Command Window
343.3500
>> J=9.81;
>> H=91.75;
>> B=70;
>> U=J*H*B*.5
U =
3.1502e+04
>> %%Pe= horizontal hydrodynamic pressure
>> %%Me= Moment about toe
>> %%Pe= 0.726*PE*H
>> %%PE= Cm*K*J*H
>> Pe=0.726*0.735*0.1*9.81*91.75*91.75
Pe =
4.4066e+03
>> %%Me= 0.412*Pe*H
>> H=91.75;
>> Me=0.412*Pe*H
Me =
1.6657e+05
>> %%X= Ml(Resisting moment)/Vl(Total force downward)
Activate Windows
Go to Settings to activate Windows.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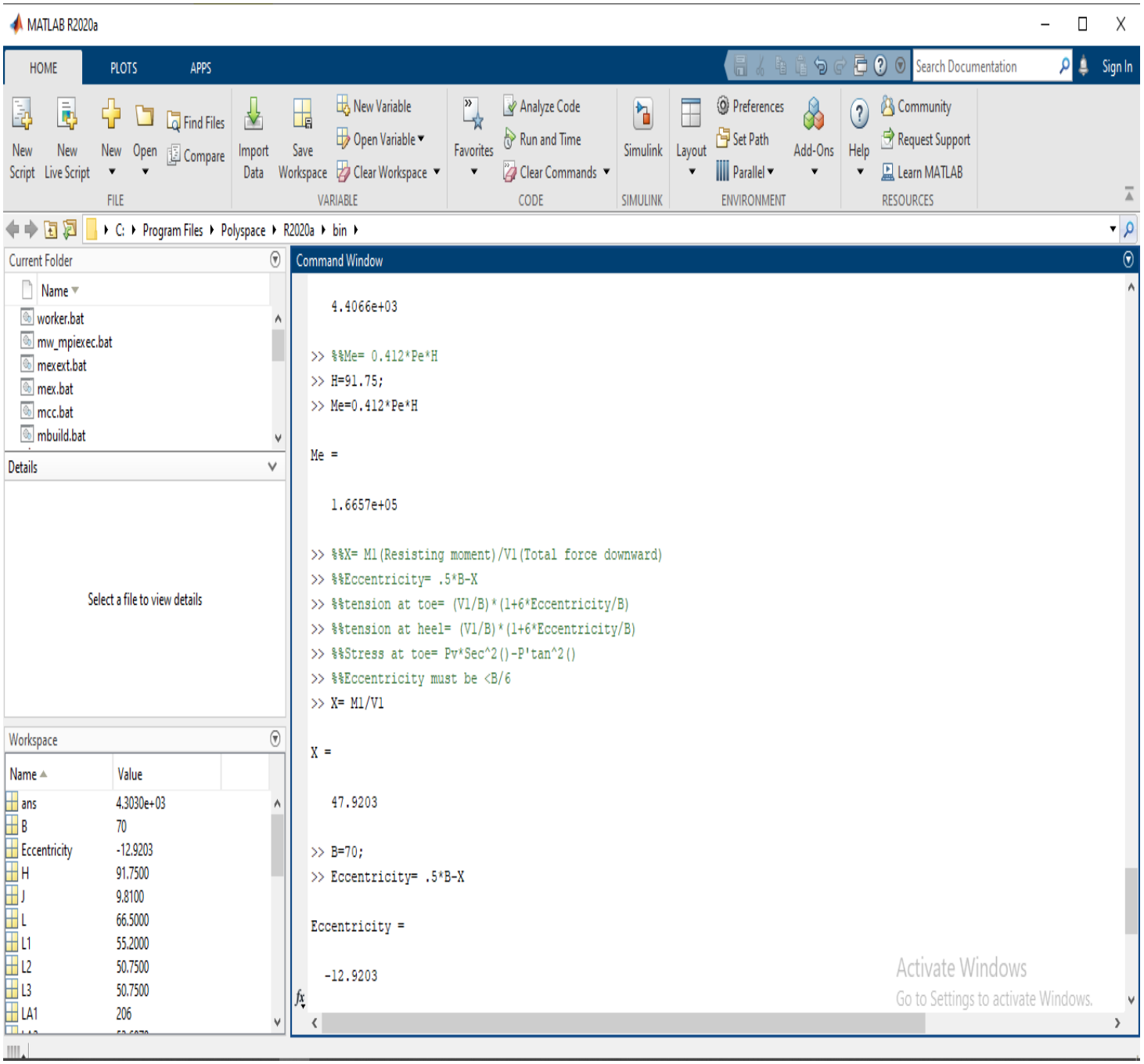
Value
ans 4.3030e+03
B 70
H 91.7500
J 9.8100
L 66.5000
L1 55.2000
L2 50.7500
L3 50.7500
LA1 206
LA2 53.6870
Command Window
U =
3.1502e+04
>> %%Pe= horizontal hydrodynamic pressure
>> %%Me= Moment about toe
>> %%Pe= 0.726*PE*H
>> %%PE= Cm*K*J*H
>> Pe=0.726*0.735*0.1*9.81*91.75*91.75
Pe =
4.4066e+03
>> %%Me= 0.412*Pe*H
>> H=91.75;
>> Me=0.412*Pe*H
Me =
1.6657e+05
>> %%X= M1(Resisting moment)/V1(Total force downward)
>> %%Eccentricity= .5*B-X
>> %%tension at toe= (V1/B)*(1+6*Eccentricity/B)
>> %%tension at heel= (V1/B)*(1+6*Eccentricity/B)
>> %%Stress at toe= Pv*Sec^2()-P'tan^2()
>> %%Eccentricity must be <B/6
>>
Activate Windows
Go to Settings to activate Windows.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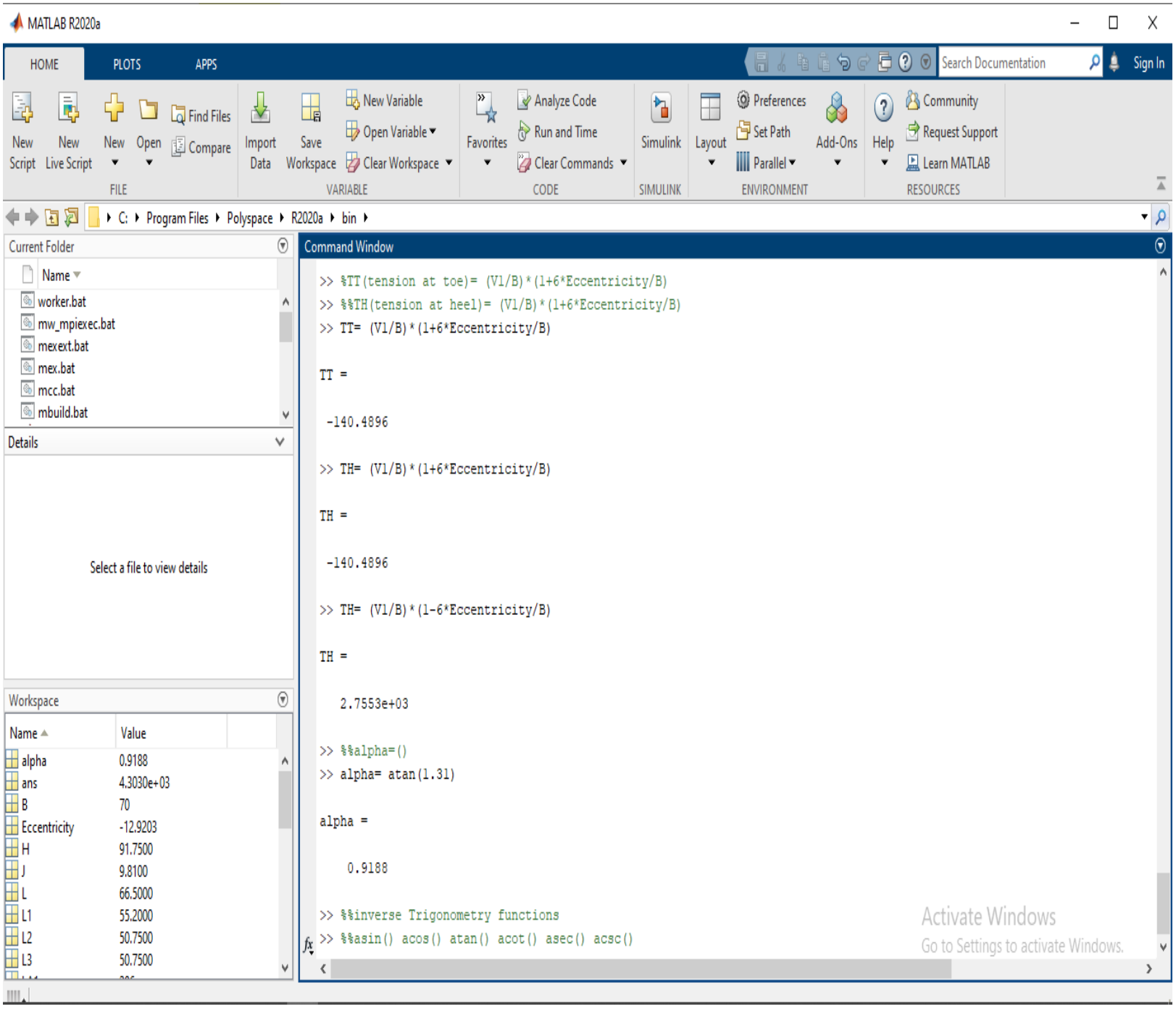
Workspace
Name
Value
ans 4.3030e+03
B 70
Eccentricity -12.9203
H 91.7500
J 9.8100
L 66.5000
L1 55.2000
L2 50.7500
L3 50.7500
LA1 206
Command Window
4.4066e+03
>> %%Me= 0.412*Pe*H
>> H=91.75;
>> Me=0.412*Pe*H
Me =
1.6657e+05
>> %%X= Ml(Resisting moment)/Vl(Total force downward)
>> %%Eccentricity= .5*B-X
>> %%tension at toe= (Vl/B)*(1+6*Eccentricity/B)
>> %%tension at heel= (Vl/B)*(1+6*Eccentricity/B)
>> %%Stress at toe= Pv*Sec^2()-P'tan^2()
>> %%Eccentricity must be <B/6
>> X= Ml/Vl
X =
47.9203
>> B=70;
>> Eccentricity= .5*B-X
Eccentricity =
-12.9203
Activate Windows
Go to Settings to activate Windows.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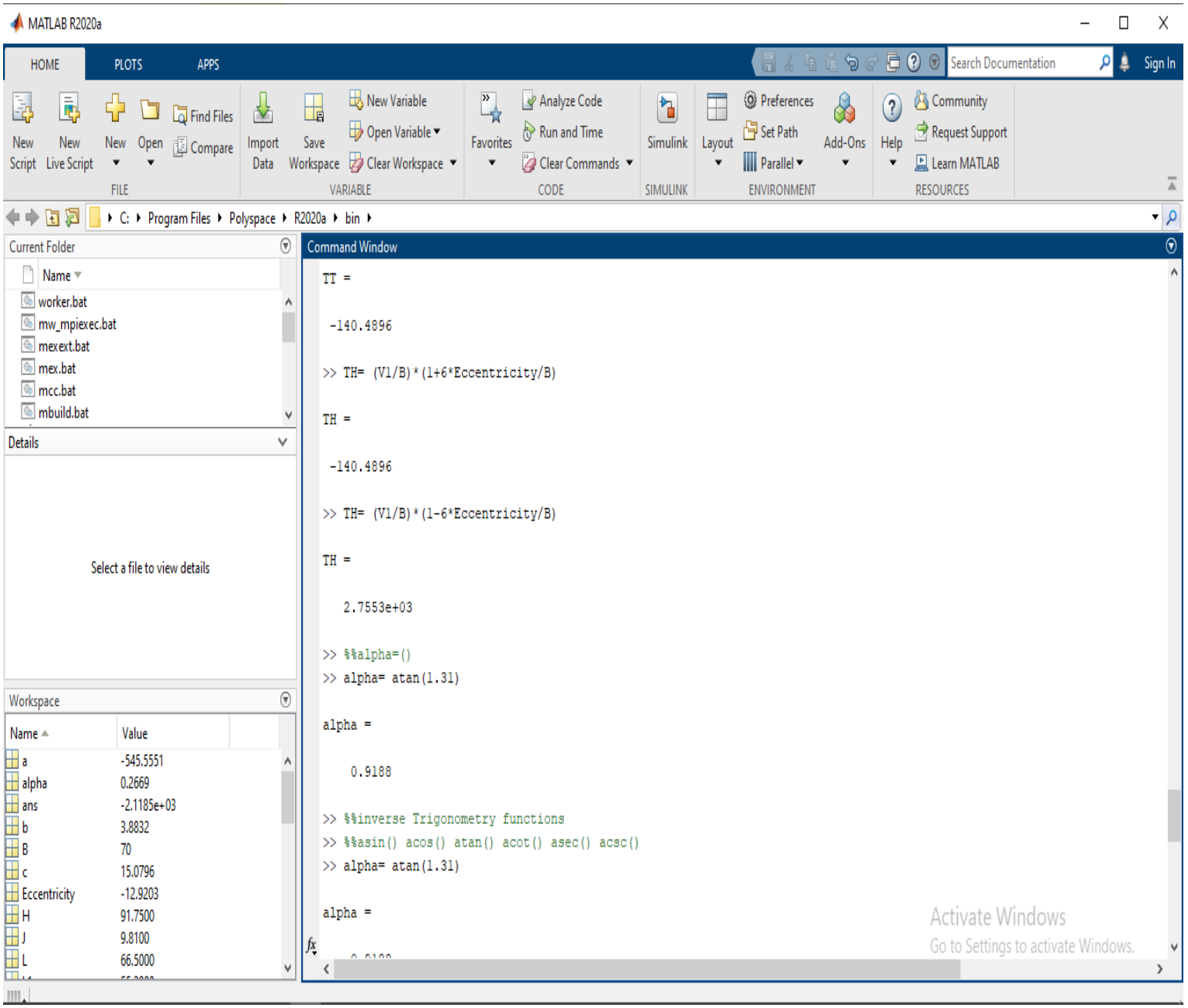
Current Folder
Name
worker.bat
mw_mpiexec.bat
mexext.bat
mex.bat
mcc.bat
mbuild.bat
Details
Select a file to view details
Workspace
Name
Value
alpha 0.9188
ans 4.3030e+03
B 70
Eccentricity -12.9203
H 91.7500
J 9.8100
L 66.5000
L1 55.2000
L2 50.7500
L3 50.7500
Command Window
>> %TT(tension at toe)= (V1/B)*(1+6*Eccentricity/B)
>> %%TH(tension at heel)= (V1/B)*(1+6*Eccentricity/B)
>> TT= (V1/B)*(1+6*Eccentricity/B)
TT =
-140.4896
>> TH= (V1/B)*(1+6*Eccentricity/B)
TH =
-140.4896
>> TH= (V1/B)*(1-6*Eccentricity/B)
TH =
2.7553e+03
>> %%alpha=()
>> alpha= atan(1.31)
alpha =
0.9188
>> %%inverse Trigonometry functions
>> %%asin() acos() atan() acot() asec() acsc()
Activate Windows
Go to Settings to activate Windows.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Set Path
Parallel
Add-Ons
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mexext.bat
mex.bat
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Details
Select a file to view details
Workspace
Name
Value
a -545.5551
alpha 0.2669
ans -2.1185e+03
b 3.8832
B 70
c 15.0796
Eccentricity -12.9203
H 91.7500
J 9.8100
L 66.5000
Command Window
TT =
-140.4896
>> TH= (V1/B)*(1+6*Eccentricity/B)
TH =
-140.4896
>> TH= (V1/B)*(1-6*Eccentricity/B)
TH =
2.7553e+03
>> %%alpha=()
>> alpha= atan(1.31)
alpha =
0.9188
>> %%inverse Trigonometry functions
>> %%asin() acos() atan() acot() asec() acsc()
>> alpha= atan(1.31)
alpha =
Activate Windows
Go to Settings to activate Windows.

3.15 KEEPING TRACK OF YOUR WORK SESSION

where file name may any discretional named decioded on. The perform diaryis beneficial id you'd wish saved lots of an entire Matlab sessions. They have save all the in puts and out puts as they are seems with in the matlab window.. once you wish to prevent the recording, enter diary off. If you wish to start out recording once more,entered dairyon . the file which is createdcould be a straightforward document. It would be openif by the associate degree editor or a data processings program & emended to get rid of ecxtaneous materials, or toor feature you comment. You can use the perform sort to look at the diary file otherwise you will edit in a very text editor or print. This commannd is beneficial, for instance within the method of making ready a prep or workplace submission.

3.16 GETTING THE HELP

To view the net documentation, choose Matlab facilitate from facilitate menuor or Matlab facilitate directed within the command windowthe popular methodology is to use the assistance Browser. The Help Browser is started by choosing the? Icons from the desktoptool bar. On the opposite hand, data concerning any command is accessible by typewriting

<<help command

Other way to urge assistance to be used the looks foe command. The lookfor command differs from the assistancecommand. the assistance command searches for a precise perform namematch, while the look foe while the lookfor command searches the fast outline info in every perform for a match. for instance, suppose that we have a tendency to were searching for a perform to require the inverse of a matrix. Since Matlab doesn't have a perform named inverse, the command facilitate inverse can turn out nothing. On the oppositehand, the command look for inverse can produce careful info, which incorporates the perform of interest, inv.

<<lookfor command

Note – on this specific times of our studies, it's vital to emphasise one main purpose. Because Matlab may be a Brobdingnagian program; it's not possible to hide all the main points of every perform onebyone. Howeverwe are going to provide you with data the way to get facilitate. Here square measure some examples

<< help sqrt

CHAPTER 4

4.1 Results and Discussions:

The maximum worth of stress happens at the heel that's 255 and could be a compressive stress just in case of reservoir empty condition. Moderately tensile stress is generated at the downstream face that's two.75x10^3. As obtained in manual calculations, that the resultant of forces lies close to the heel and compressive and tensile stresses generate at the heel and toes severally. it's been discovered that the direction of vertical earthquake force doesn't have outstanding rule out the strain distribution results however the utmost displacement at the crest is somewhat lesser if this force acts upward. In reservoir empty condition the direction of horizontal earthquake force is condemnatory if it acts towards upstream face since it'll cause overturning of the dam as an entire. In reservoir full condition compressive stress generates at the toe and tensile stress at the heel, it additionally has been noted that stress distribution pattern is somewhat dissimilar for manual

CHAPTER 5

5.1CONCLUSION

Establishing this work establishes a benefaction to the study of concrete gravity dams in addition on escalating the judgement of the sector of stress in these structures once subject to varied static and dynamic masses. to the current finish, a study of the most styles of masses and the way they act on gravity dams was carried in addition as, creating a program within the framework of Matlab. This created it probable to search out out masses and stresses in concrete gravity dams submitted to numerous assortment of static and dynamic masses (earthquakes). The Matlab code written for analyzing the steadiness of the dam was tested to be correct because the results obtained from Matlab matched specifically thereupon of assorted issues chosen from completely different textbooks. The Matlab code inscribed was terribly effective and extremely time saving and it will be applied to any dam. The Matlab code written works for gravity dam to search out the forces functioning on it to check the steadiness of the dam.

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