Distributed Elastic Support Data for the Human Palm

Recent data has been published on the human palm as an elastic foundation. The foundation modulus should be reported with the units of $(N/m^2)/m$. The reference paper used an indentor having a diameter of 2 mm and an area of 3.142 mm^2. The tabulated point stiffnesses (N/mm) need to be divided by the indentor area to get the distributed foundation modulus, N/mm^3.

For example, the distal medial palm average point stiffness of 2.34 N/mm should have been reported as k =0.745 N/mm^3 =7.45e8 $(N/m^2)/m$.

Journal of Biomechanics 46 (2013) 2644–2650

Contents lists available at ScienceDirect

Journal of Biomechanics

journal homepage: www.elsevier.com/locate/jbiomech
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Stiffness map of the grasping contact areas of the human hand

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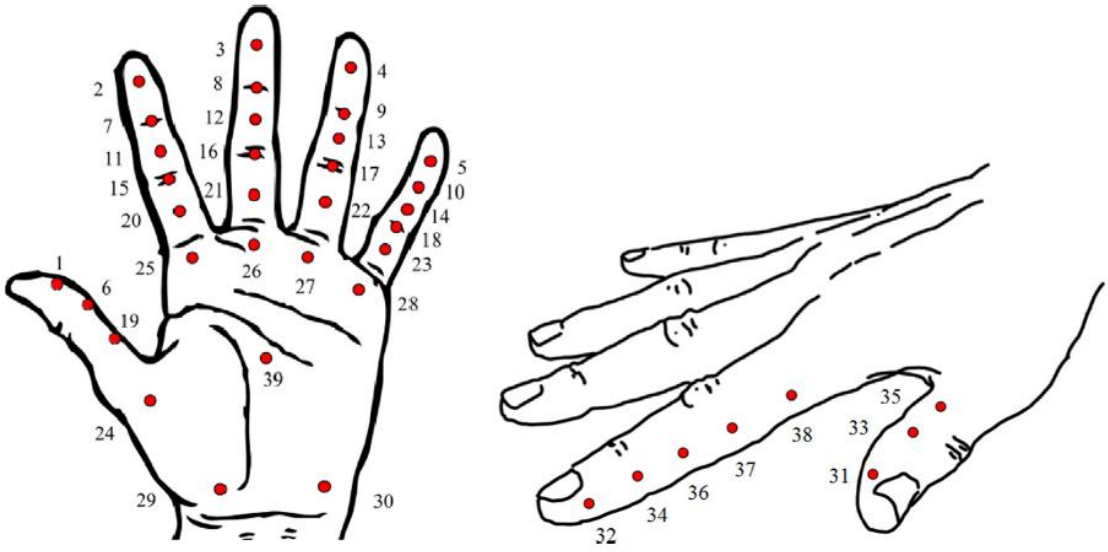


Fig. 1. Location of the points for measurement on the hand.

Table 3
Classification of points in regions with similar mean stiffness.

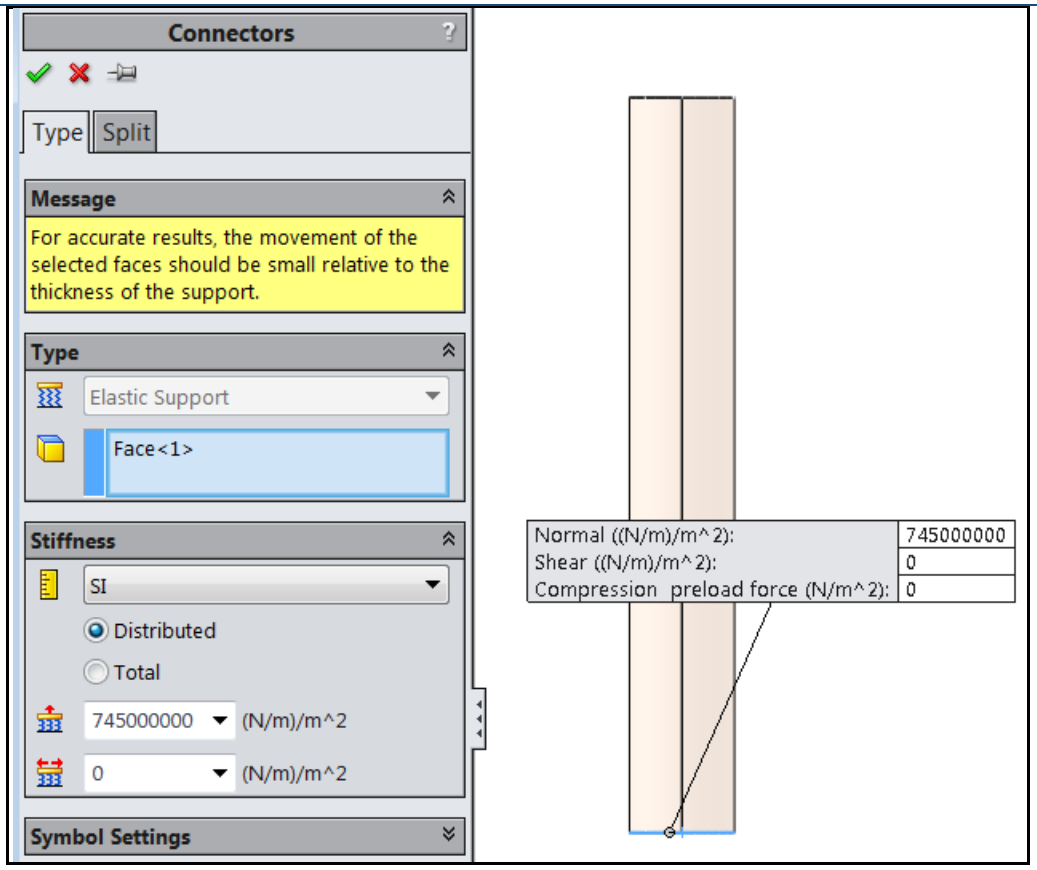
Region	Nick	Points
Distal phalange of thumb	DP_T	1
Distal phalanges of fingers	DP_F	2,3,4,5
Distal interphalangeal joints	Joint_DIP	7,8,9,10
Proximal interphalangeal joints	Joint_PIP	6,15,16,17,18
Intermediate phalanges	MP	11,12,13,14
Proximal phalanges	PP	19,20,21,22,23
Medial and proximal palm	M&P_Palm	24,29,30,39
Distal palm middle finger	D_Palm_M	26
Rest of distal palm	D_Palm	25,27,28
Lateral side of distal phalange of thumb	Lat_DP_T	31
Lateral side of intermediate phalange of index	Lat_MP_I	36
Lateral side of joints of thumb and index	Lat_Joint	33,34,37
Rest of lateral side of proximal and distal phalanges	Lat_P&D	32,35,38

Table 4
Mean (SD) of the stiffness (N/mm) by region and force interval (20 subjects).

	Force interval					
	s01	s12	s23	s34	s45	s56
DP_T	0.23(0.04)	1.37(0.44)	2.45(0.73)	3.25(1.00)	4.20(1.37)	4.67(1.81)
DP_F	0.27(0.04)	1.86(0.63)	3.61(1.27)	4.72(1.41)	6.12(1.61)	6.88(1.94)
Joint_DIP	0.50(0.13)	2.38(1.12)	3.96(1.55)	4.83(1.33)	6.01(1.79)	6.64(2.14)
Joint_PIP	0.80(0.30)	2.76(1.13)	3.56(1.45)	3.66(1.44)	4.00(1.69)	4.16(1.74)
MP	0.35(0.09)	1.48(0.57)	2.60(1.06)	3.45(1.15)	4.41(1.53)	4.64(1.63)
PP	0.28(0.07)	1.18(0.43)	1.95(0.90)	2.33(0.95)	2.88(1.30)	2.95(1.31)
M&P_Palm	0.24(0.09)	0.55(0.18)	0.74(0.26)	0.83(0.30)	1.03(0.41)	1.10(0.55)
D_Palm_M	0.36(0.12)	1.71(0.86)	2.38(0.94)	2.16(1.20)	2.47(1.45)	1.88(0.96)
D_Palm	0.30(0.12)	1.25(0.60)	1.78(0.91)	1.95(1.16)	2.03(0.98)	1.87(0.90)
Lat_DP_T	0.44(0.12)	1.45(0.59)	1.98(0.75)	2.17(0.61)	2.75(0.79)	2.83(0.97)
Lat_MP_I	0.93(0.42)	3.10(1.54)	3.73(1.31)	4.02(1.19)	4.98(1.67)	4.62(1.70)
Lat_Joint	0.92(0.28)	4.03(1.57)	5.52(2.15)	5.40(2.16)	6.12(2.28)	5.76(2.07)
Lat_P&D	0.50(0.18)	2.67(1.47)	3.06(1.24)	3.19(1.31)	3.43(1.39)	3.51(1.74)

To validate the SW elastic foundation model a part was created with a 2 mm diameter and a length of 12 mm (to reduce large deflection problems). It was made of alloy steel. It was considered as an indentor pressing on the palm. The top end was loaded axially with 2.34 N. The bottom end was assumed to be the palm and was assigned an elastic support modulus of 7.45e8 N/mm^3. This part should mainly translate vertically (y-direction) exactly 1 mm if the part were perfectly rigid, but will be a little less than that due to deformation of the steel.

The cylindrical surface was restrained in the radial and circumferential directions to prevent rigid bidy motion (but allow y-direction motion). The computed y-displacement using the iterative solver was 0.996 mm which matches the expected result (the direct solver failed).


Connectors
Type
Split
Message
For accurate results, the movement of the selected faces should be small relative to the thickness of the support.
Type
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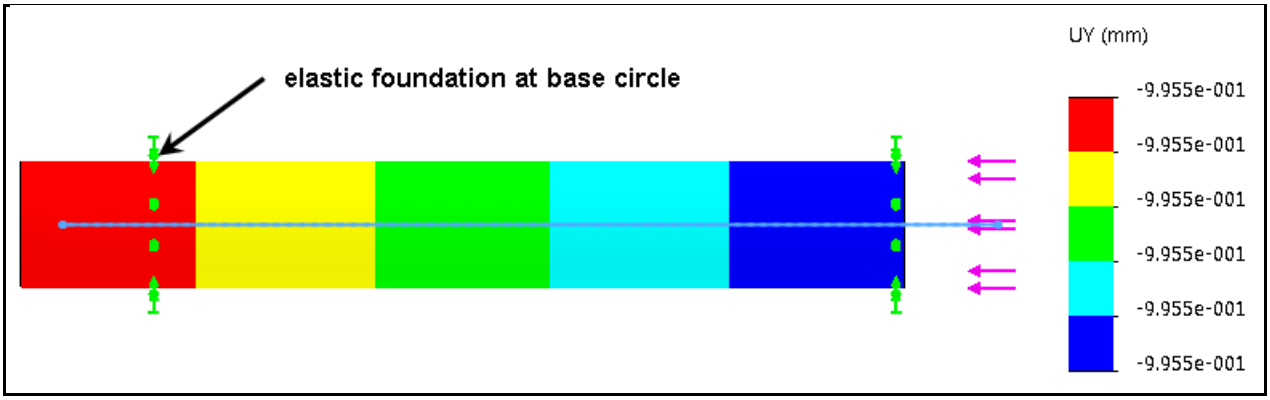
Face<1>
Stiffness
SI
Distributed
Total
745000000
(N/m)/m^2
0
(N/m)/m^2
Symbol Settings
Normal ((N/m)/m^2):
Shear ((N/m)/m^2):
Compression preload force (N/m^2):
745000000
0
0


elastic foundation at base circle
UY (mm)
-9.955e-001
-9.955e-001
-9.955e-001
-9.955e-001
-9.955e-001
-9.955e-001