

Data Descriptor

Passive biaxial tensile dataset of three main rat heart myocardia: Left Ventricle, Mid-wall and Right ventricle

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Abstract: This article presents raw data of biaxial tensile measurements of rat heart passive myocardium conducted in lab scale environment. The passive myocardium of the rat was divided into three regions, namely: left ventricle, mid-wall and right ventricle. The biaxial dataset of passive rat myocardia is presented as stress vs strain of the passive rat myocardium in various regions. The determination of valid material properties of the heart plays an important role in the development computational models. These computational models are useful in studying various scenarios and mechanisms of heart diseases. In addition, valid and accurate materials are critical in the development of new therapies. The dataset presented here is useful in the area of soft tissue mechanics including studying the mechanisms of heart diseases such as myocardial infarction. Accordingly, the evaluation of stress and strain in left ventricle, mid-wall and right ventricle was performed.

Dataset: DOI: 10.17632/y753k82jt4.2.

Dataset License: license under which the dataset is made available (CC0, CC-BY, CC-BY-SA, CC-BY-NC, etc.)

Keywords: Cardiac mechanics; Biaxial testing; Rat heart; Left ventricle mechanics; Mid-wall mechanics; Right ventricle mechanics

1. Summary

The dataset presented here is useful in the area of soft tissue mechanics and computational biomechanics for the study of the mechanisms of heart diseases such as myocardial infarction. The dataset presented here is useful to researcher communities who have interest in studying various mechanisms of heart diseases. These researchers work in the following research areas: cardiac mechanics, computational biomechanics, cardiovascular regenerative medicine, etc. The data may be used/re-used by determining the material constants of constitutive model (e.g Fung Model) to develop accurate computational models. Cardiovascular diseases are one of the leading causes of the death in the world and as such there is a need for reliable data in the study of such diseases. Various computational studies in myocardial infarction have assumed that the mechanical behaviour of myocardium is homogenous. This assumption may affect the accuracy of developed computational

models. The data presented here considers three main heart regions and the associated biaxial data is presented.

2. Data Description

The shared data shows the mechanical properties of rat myocardium in various regions. The regions considered here are the left ventricle (LV), mid-wall (MDW) and right ventricle (RV). The biaxial stress-strain tensile data (in both fibre and cross-fibre directions) of rat heart myocardium in the LV, MDW and RV are shown in Figure 1 (A-P), Figure 2 (A-O) and Figure 3 (A-N), respectively. Tables 1,2 and 3 shows the maximum tensile force at 40% strain for LV, MDW and RV regions.

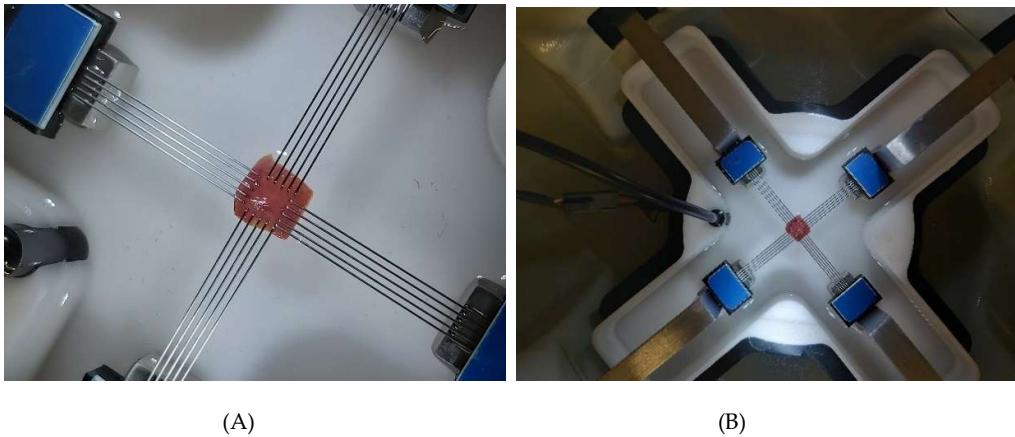
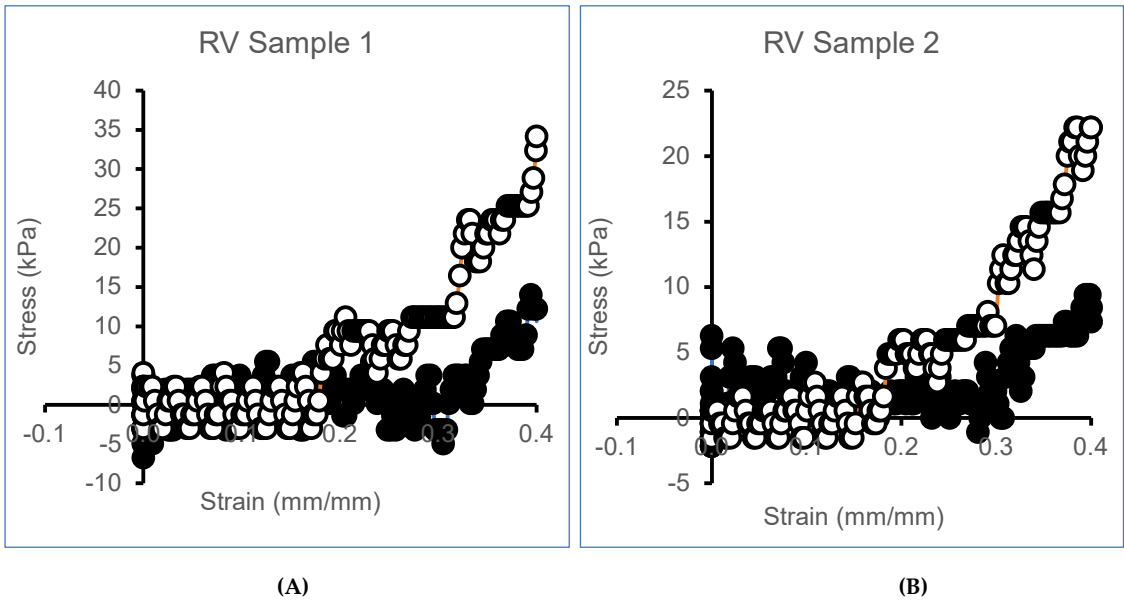
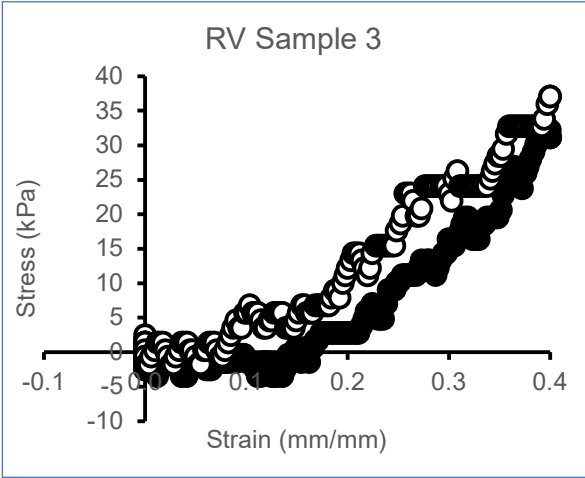
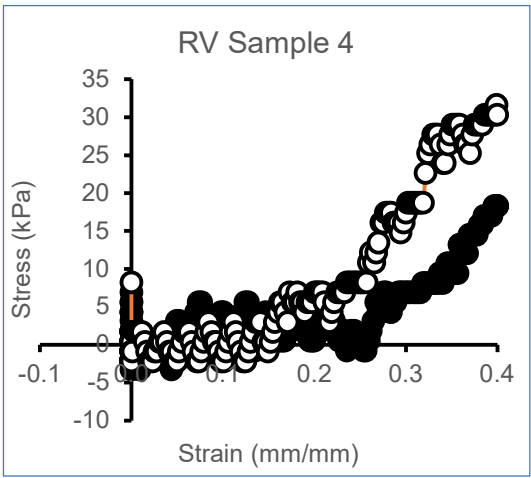


Figure 1. Experimental set-up of biaxial testing of rat heart passive myocardium. Figure 1 (A) shows the 5x5 mm LV myocardium sample and rake assembly for clamping. Figure 1 (B) shows the BioTester system used for biaxial testing of rat LV myocardium including the water bath for mimicking the body temperature of 37 °C.

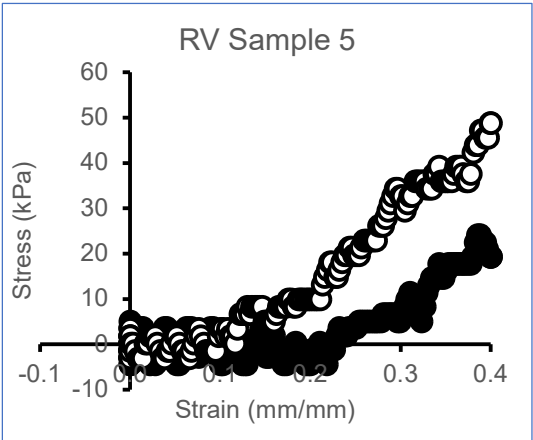




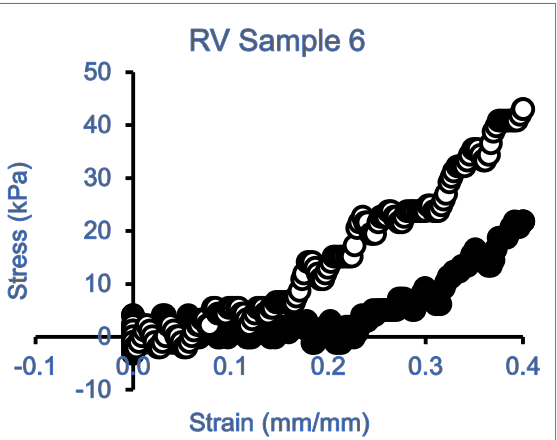
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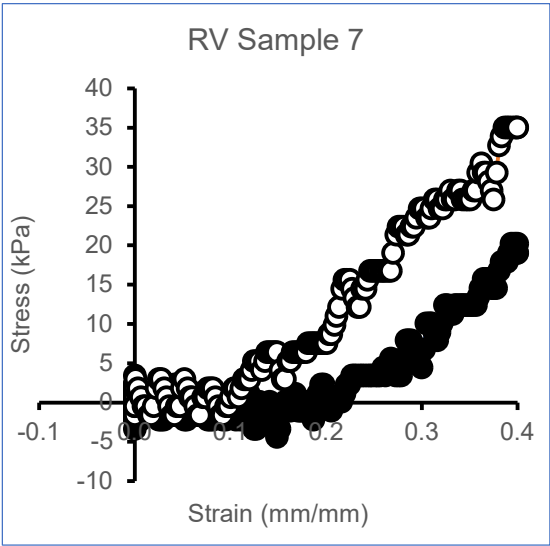
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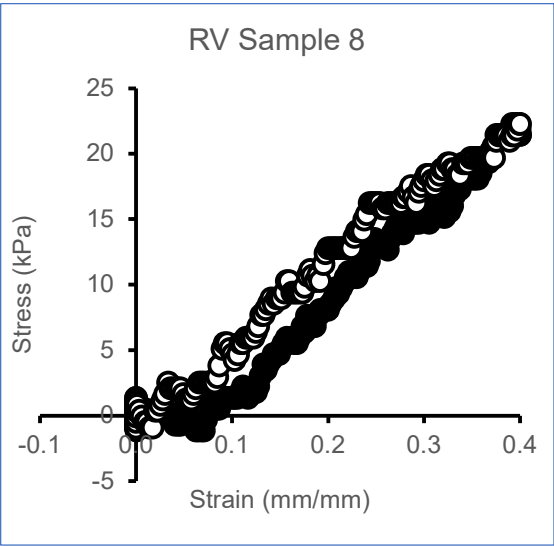
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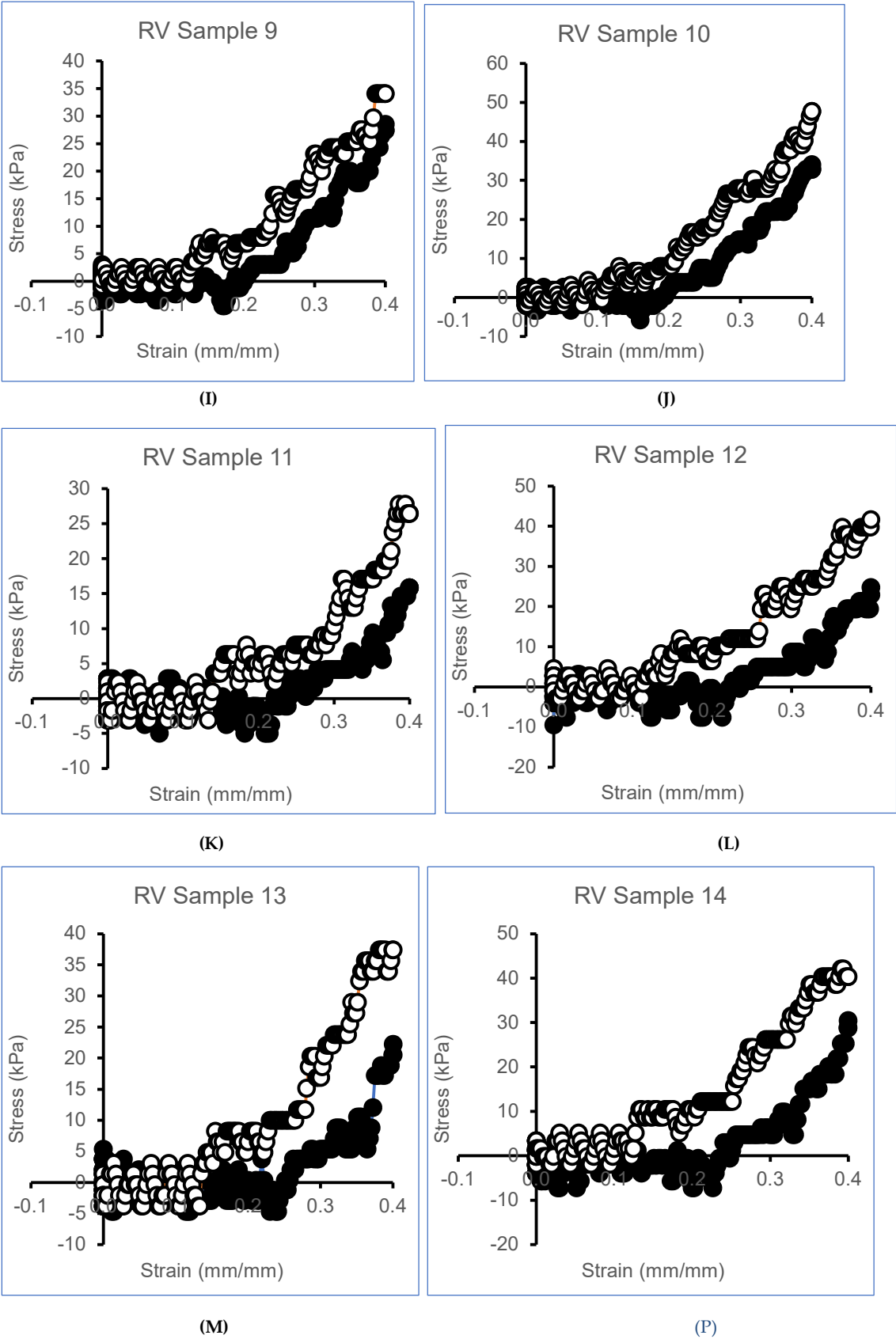
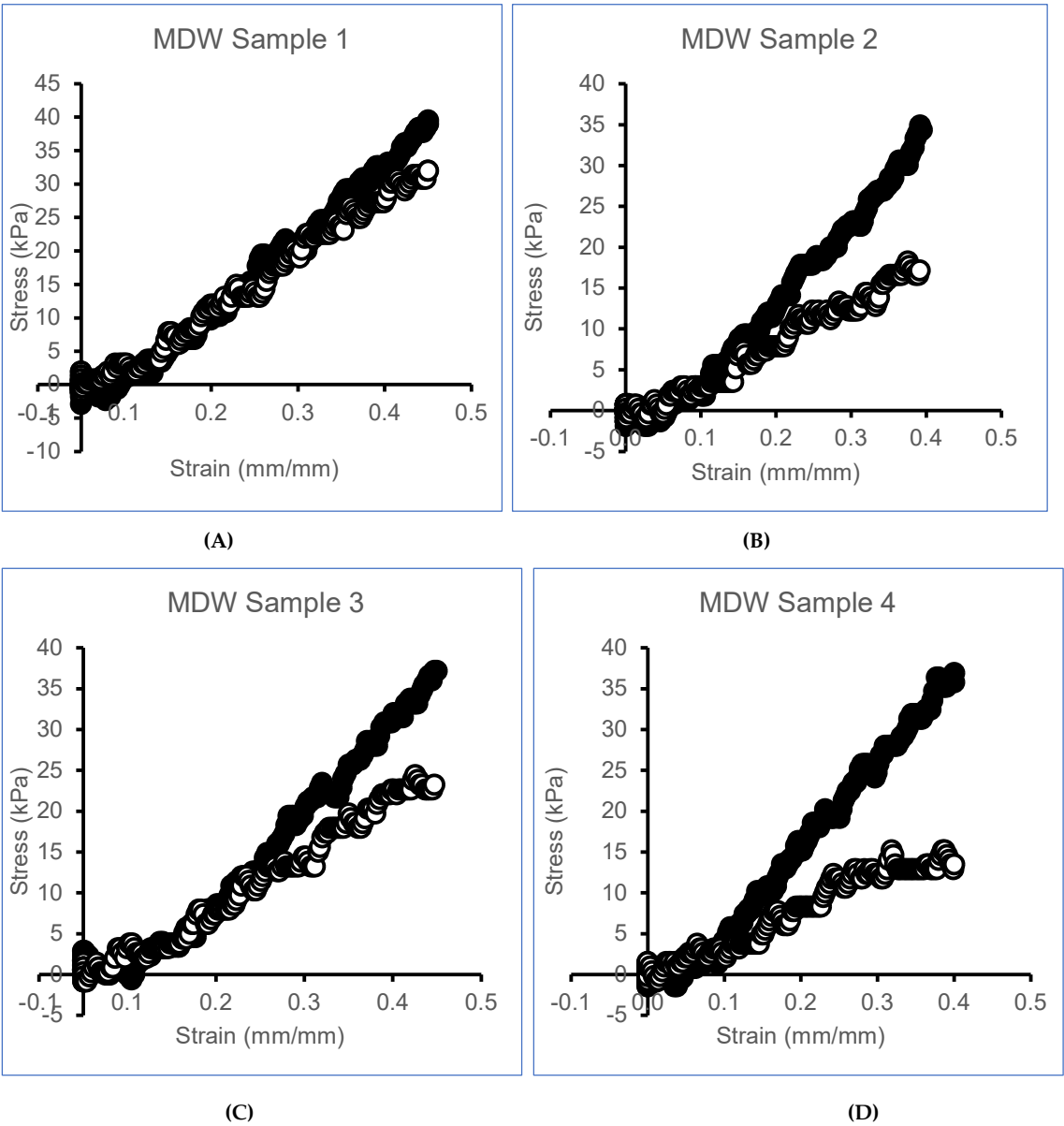
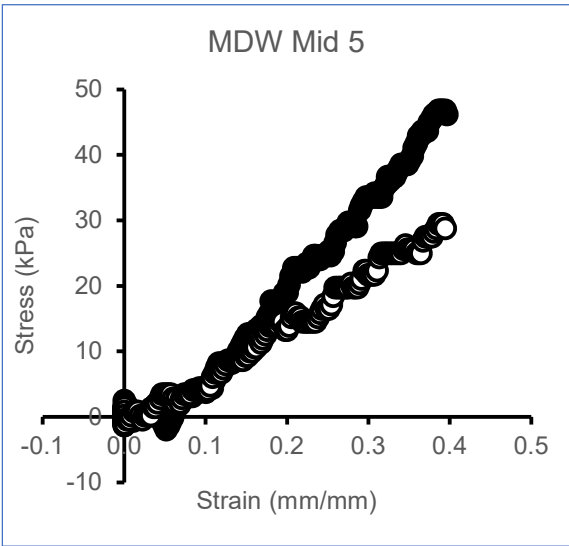
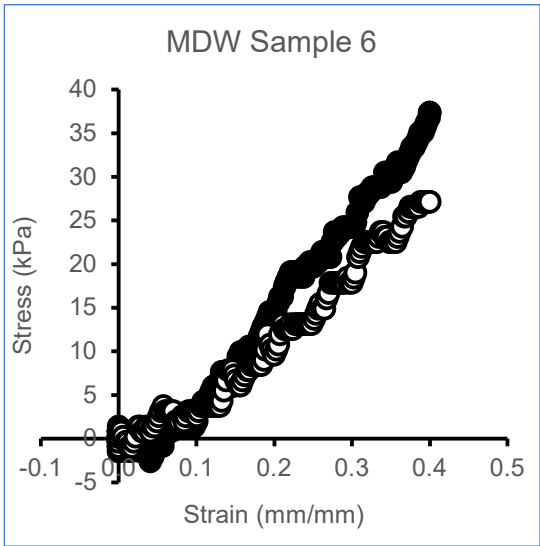


Figure 2. Stress vs strain plots of RV subjected to biaxial testing showing stress in the fibre and cross-fibre directions.

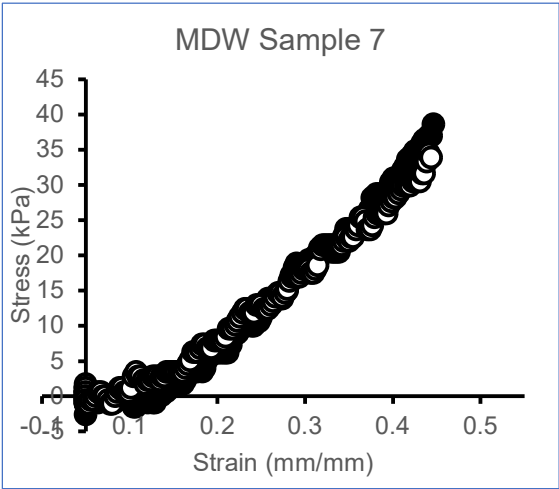




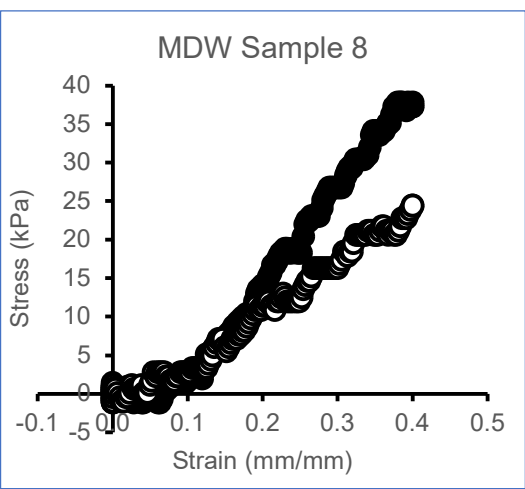
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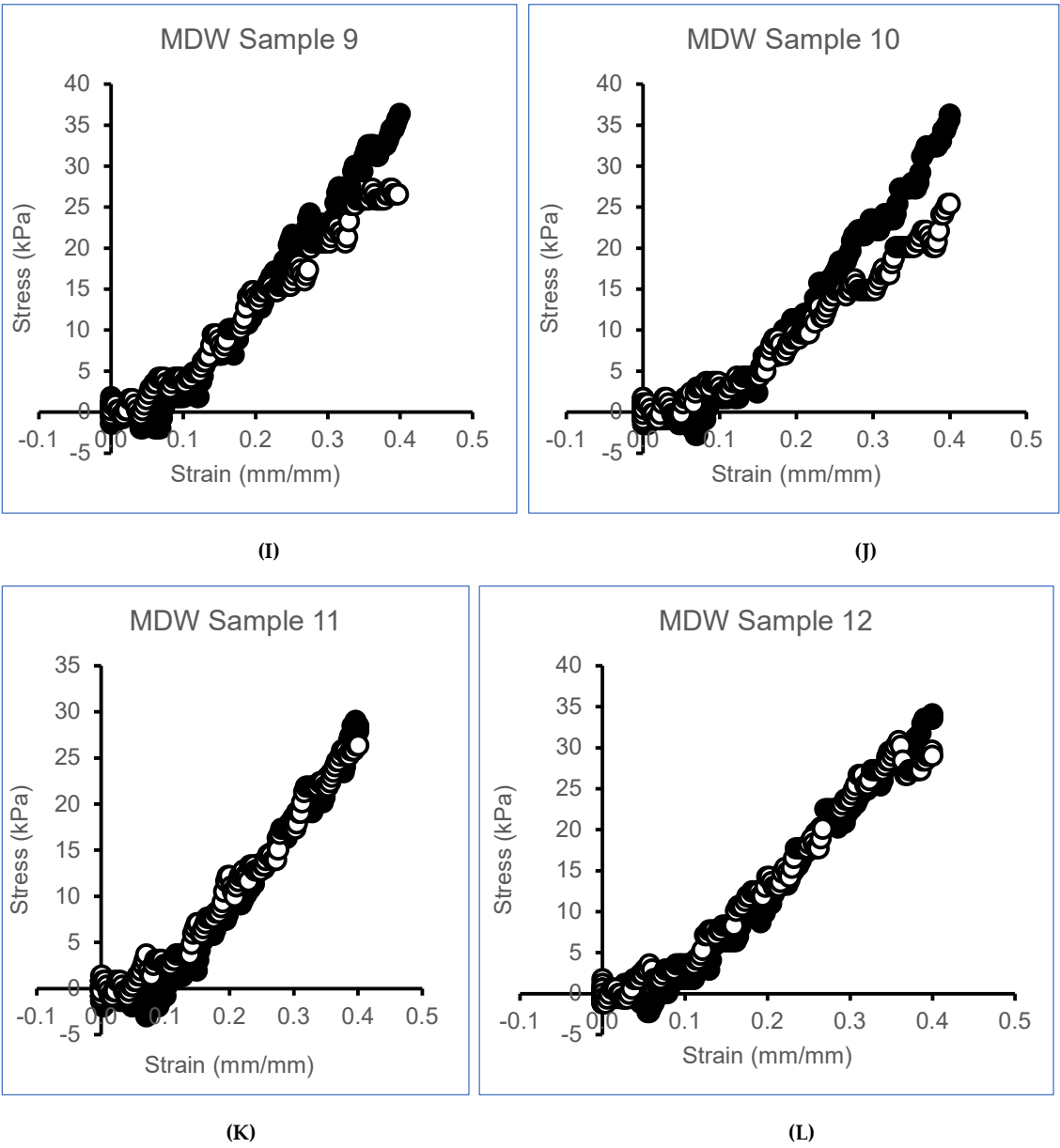
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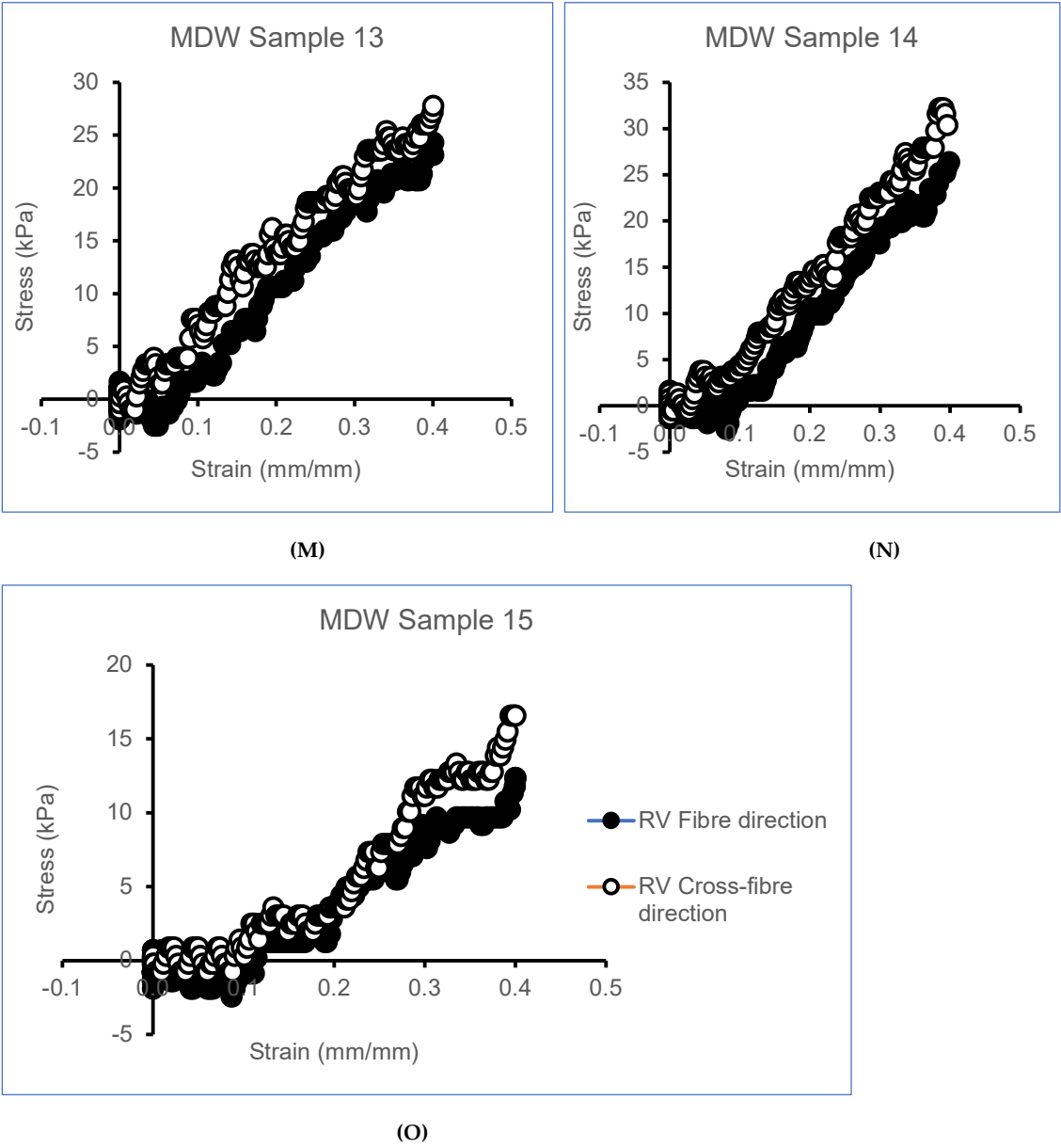
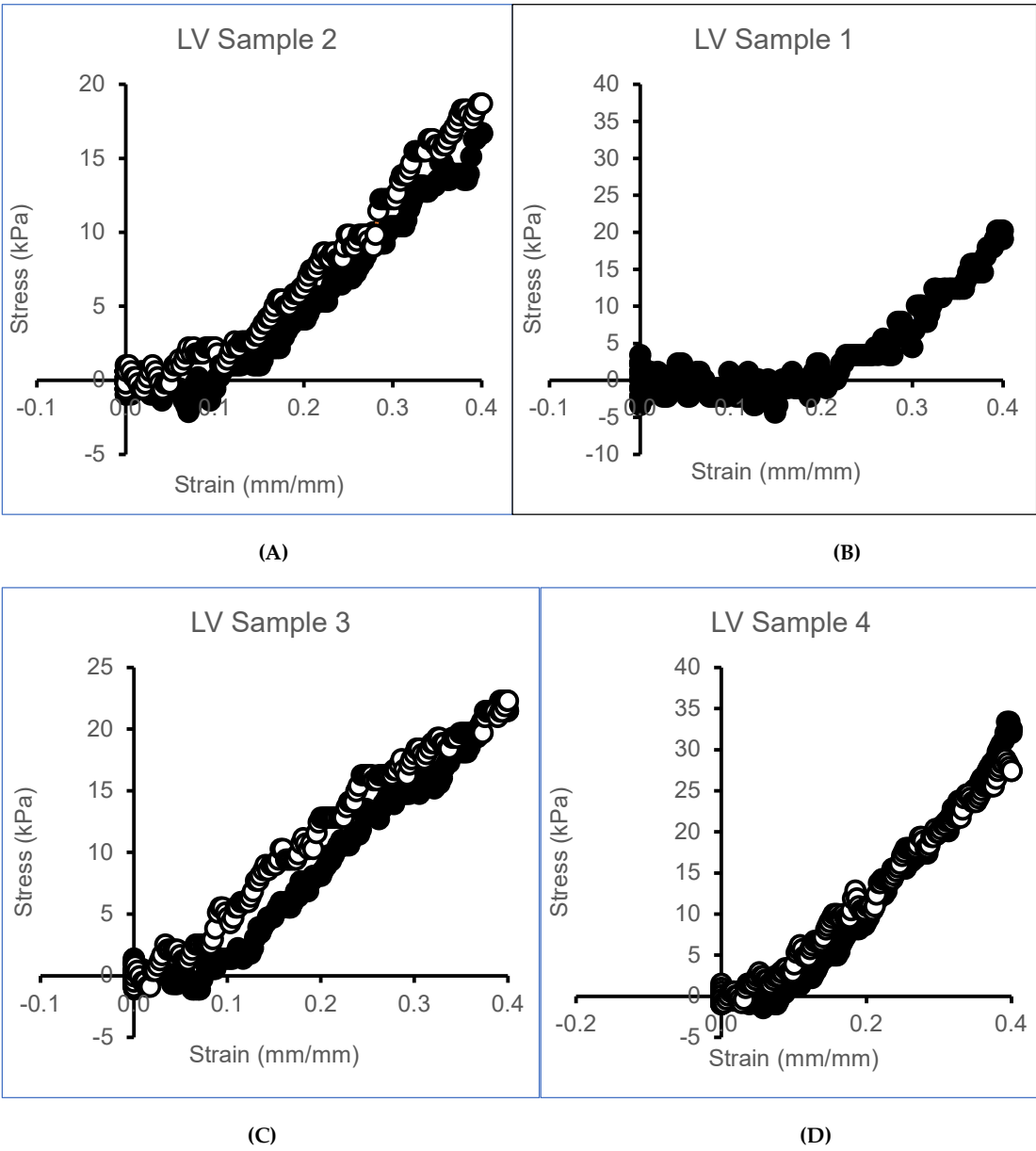
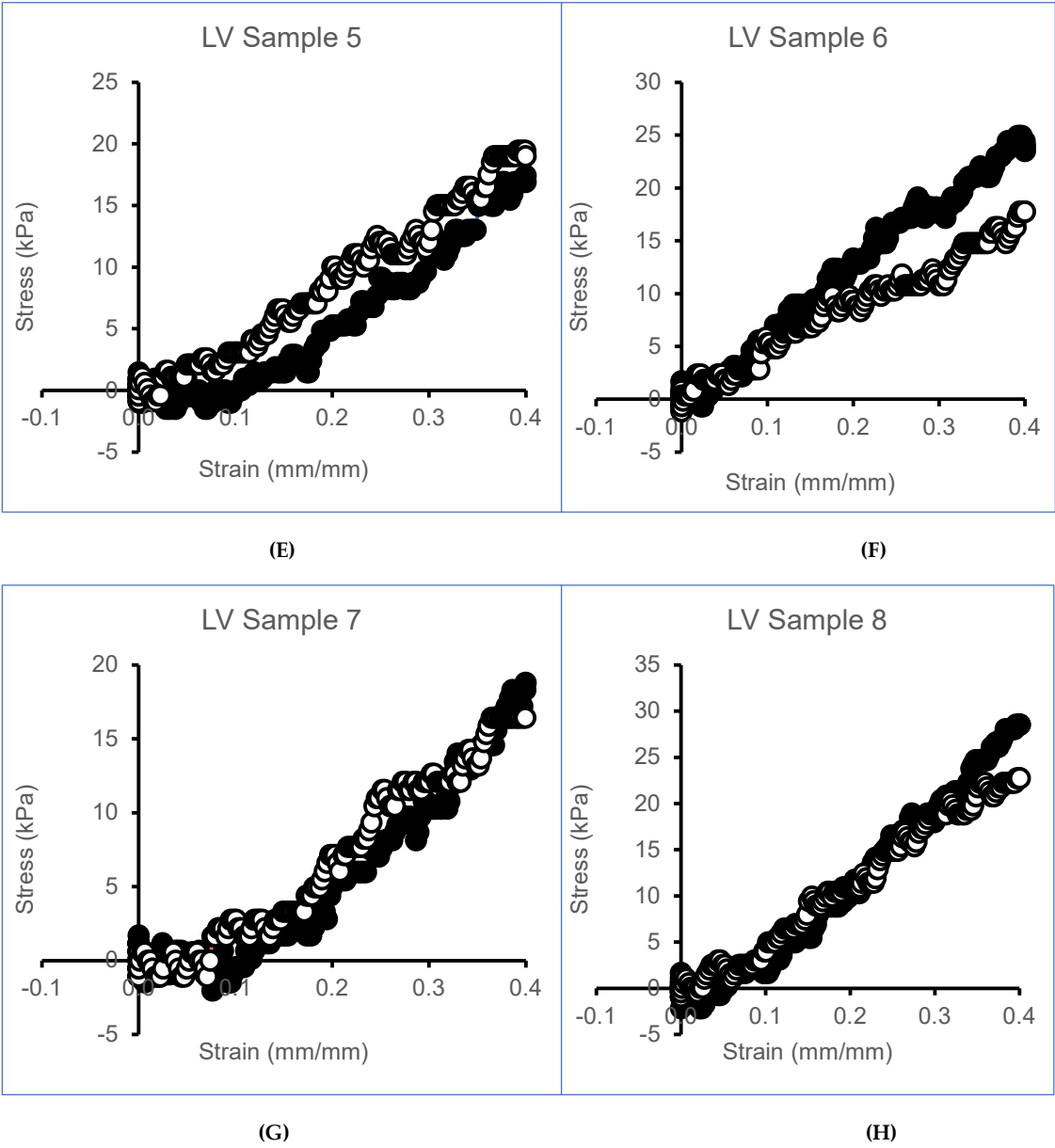
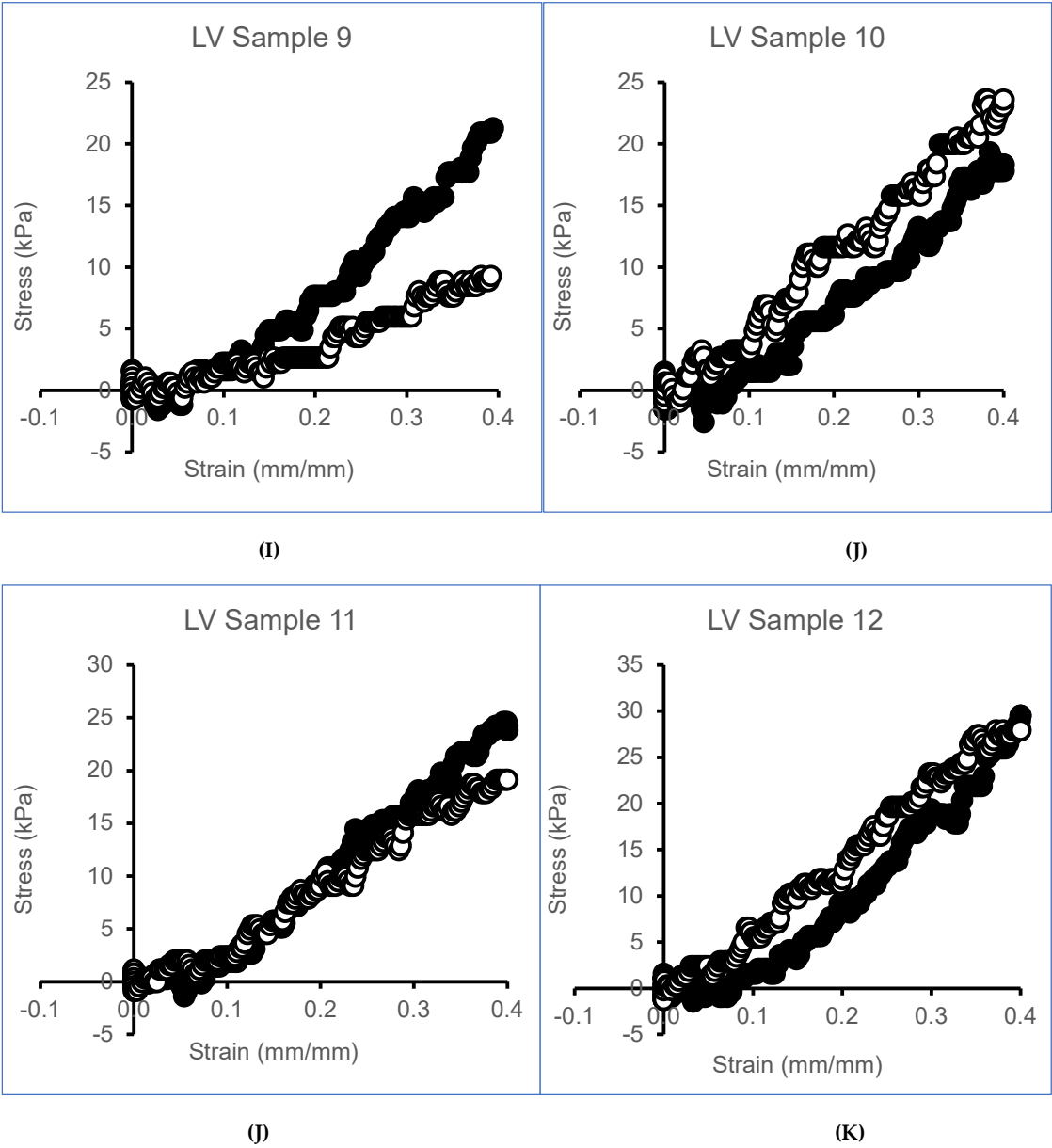


Figure 3. Stress vs Strain plots of MDW subjected to biaxial testing showing stresses in fibre and cross-fibre directions.







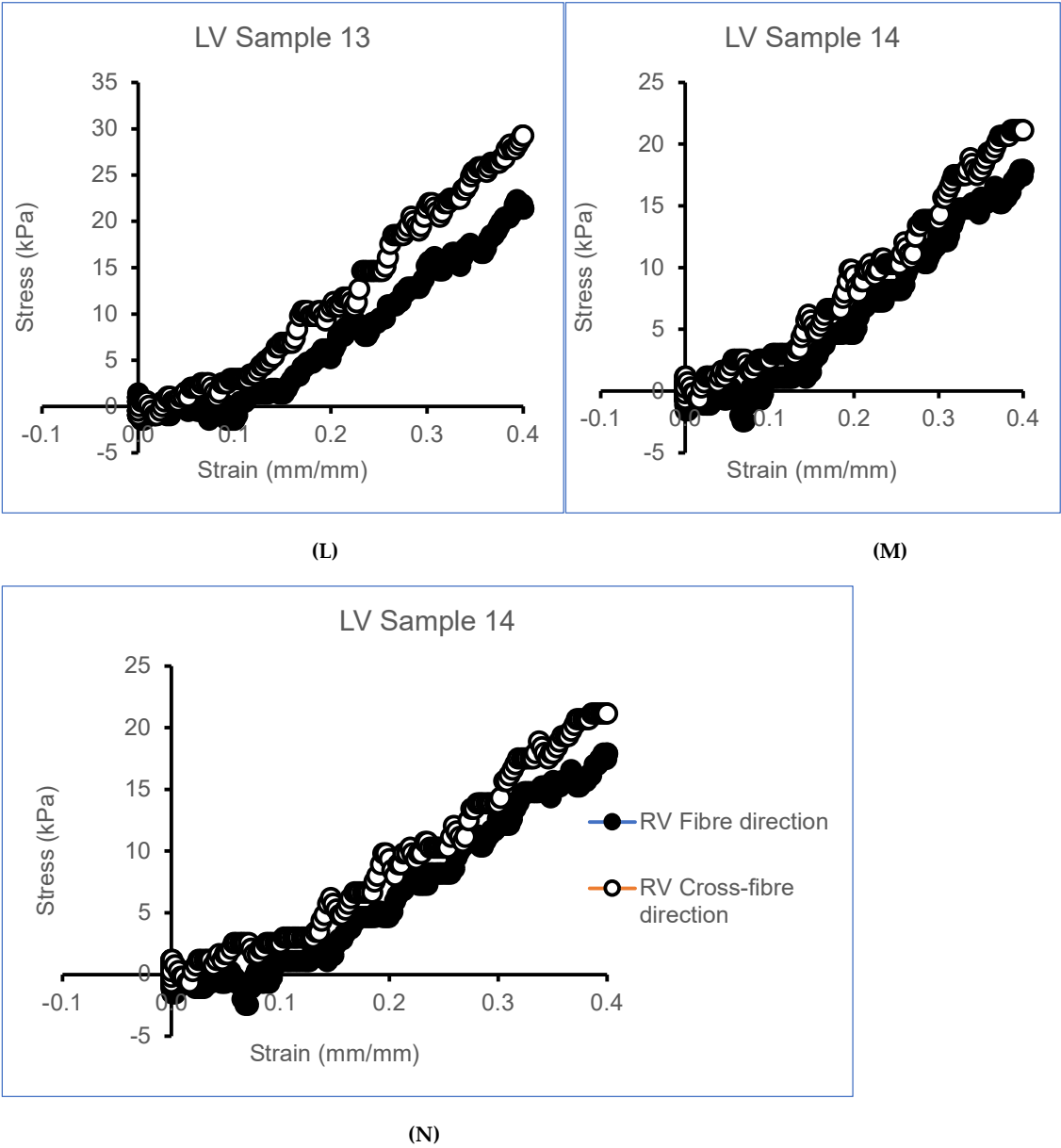


Figure 4. Stress vs Strain plots of LV subjected to biaxial testing showing stresses in fibre and cross-fibre directions.

Table1. LV maximum stress at 40% strain (n =14)

	Cross-fibre stress (kPa)	Fibre stress (kPa)
LV Sample 1	20,23	35,06
LV Sample 2	16,69	18,71
LV Sample 3	21,46	22,28
LV Sample 4	32,03	27,41
LV Sample 5	16,92	19,00

LV Sample 6	23,48	17,76
LV Sample 7	18,79	16,43
LV Sample 8	28,54	22,72
LV Sample 9	22,47	9,28
LV Sample 10	17,80	23,61
LV Sample 11	23,80	19,12
LV Sample 12	29,50	27,94
LV Sample 13	21,37	29,27
LV Sample 14	17,91	21,14
Mean	22,21	22,12

Table 2. MDW maximum stress at 40% strain (n =14)

	Cross-fibre Stress (kPa)	Fibre stress (kPa)
MDW Sample 1	39,00	31,98
MDW Sample 2	34,90	18,25
MDW Sample 3	36,00	23,24
MDW Sample 4	35,77	13,49
MDW Sample 5	46,84	27,56
MDW Sample 6	37,36	27,16
MDW Sample 7	38,64	32,77
MDW Sample 8	37,83	24,44
MDW Sample 9	37,04	27,24
MDW Sample 10	36,25	25,39
MDW Sample 11	27,90	26,36
MDW Sample 12	33,53	29,02
MDW Sample 13	23,13	27,79
MDW Sample 14	26,36	30,36
MDW Sample 15	12,34	16,58
Mean	33,53	25,44

Table 3. RV maximum stress at 40% strain (n =16)

	Cross- fibre Stress (kPa)	Fibre Stress (kPa)
RV Sample 1	7,35	22,16
RV Sample 2	31,14	37,08
RV Sample 3	18,30	30,33
RV Sample 4	19,35	48,78

RV Sample 5	21,83	43,01
RV Sample 6	20,23	35,06
RV Sample 7	21,83	43,01
RV Sample 8	20,23	35,06
RV Sample 9	21,46	22,28
RV Sample 10	28,52	34,10
RV Sample 11	34,04	47,70
RV Sample 12	15,84	26,44
RV Sample 13	24,81	41,67
RV Sample 14	20,52	37,41
RV Sample 15	30,44	40,35
RV Sample 16	27,46	15,77
Mean	22,71	35,01

3. Methods

3.1 Heart dissection and testing sample preparation

Wistar rats (200-250 gr) were euthanised by inhalation of 5% halothane. Once breathing and heartbeat had stopped, the heart was dissected out. The atria, pulmonary trunk and all unwanted soft tissues were dissected away. For the LV sample, a full cross-section of 5x5 mm was dissected out of the LV from the base to the apex of the rat heart. The samples were received from the University of Cape Town and carried to the University of South Africa in a temperature-controlled box. The mechanical tests were then conducted immediately after receipt of the samples. This study was approved by the Faculty of Health Sciences Animal Ethics Committee of the University of Cape Town on 6 May 2019 under reference number FHS AEC REF 019-019

3.2 Biaxial tensile test

CellScale Biaxial testing system was used to capture the mechanical properties of all tissue samples. All prepared tissue samples were mounted in the custom biaxial tensile material testing apparatus (BioTester 5000 CellScale, Waterloo, ON, Canada®) specifically designed for soft tissue mechanical testing. The BioTester 5000 biaxial system is installed with a unique system that uses rakes for piercing the tissue. In this test, the four rakes (see Figure 1) are utilised to clamp the tissue sample for biaxial tensile testing. Average of 14 samples for LV, MDW and RV were harvested and subjected to equi-biaxial tensile testing. The major dimensions such as length, width and the thickness of each sample were measured using a Vernier calliper. To ensure the accuracy of the measurement, each dimension was measured four times and average dimensions were then utilised for further processing. Before collecting data, the precondition was conducted by applying a 10% strain on the sample at a strain rate of 0.001/s. A preload of 5mN was applied for 0.53 seconds. To maintain hydration and mimicking the body temperature, saline 0.91% w/v of NaCl was placed in the bath and heated to 37 °C and maintained for the duration of testing. Each sample was subjected to 40% biaxial strain in the fibre and cross-fibre direction simultaneously at strain rate of 40% strain/5 seconds. 40% strain was selected to be the physiological magnitude of rat heart.

4. Discussion

Mechanical properties of soft tissues have been utilized for decade in studying the mechanisms of diseases [1-5]. Accuracy of mechanical properties of soft tissues is vital in the developed of computational models. Biventricular subject specific heart models have been used for decades to study various stages of cardiovascular diseases including myocardial infarction [6, 7]. The accurate computational models are critical in the development of therapies for different diseases [2, 8, 9]. Currently, when building the computational models, the mechanical properties of the heart are assumed to be the same in all regions of the heart [10-14]. This studies clearly shows that it is important to consider the different material properties of all regions in the heart. This is so because it is clear from the presented data that the is a different mechanical property in different heart regions, i.e. RV, MDW and LV.

Supplementary Materials: No supplementary data is available except data that is available here DOI: 10.17632/y753k82jt4.2.

Author Contributions: Conceptualization, T.F., F.N. and N.D.; methodology, F.N.; formal analysis, F.N.; investigation, F.N.; resources, F.N. and H.N.; data curation, F.N.; writing—original draft preparation, F.N.; writing—review and editing, H.M. T.F. and N.D.; visualization, F.N.; supervision, F.N.; project administration, H.M. and F.N.; funding acquisition, F.N. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: The dataset presented in this paper can be found publicly deposited here DOI: 10.17632/y753k82jt4.2.

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Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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