Authors' Responses

Dear Editor:

We sincerely thank you for handling the second round of review of our revised manuscript "Experimental Investigation of the Direct Shear Strength Parameters of Compacted Snow." We have carefully addressed each of the three points raised by the reviewer. The detailed responses are presented below. The author's responses are marked in blue, and the changes made to the original manuscript are marked in red. Additionally, the authors have expanded Table 4 (Compacted snow shear strength parameters) to include all **8** density levels from 300 to 650 kg·m^{-3}. The comments and corresponding responses are as follows:

Responses to the Comments of Reviewer:

Comment 1: First, I was convinced by the authors' response regarding the ability of neural networks to capture non-linearity and interactions between variables. Nevertheless, I would prefer if the statement in line 363 were toned down regarding the superiority of neural networks. Other methods, such as Random Forests, Gaussian Processes, and several additional machine learning approaches, are also capable of handling non-linearity and variable interactions. I suggest acknowledging that neural networks were one choice among several suitable methods.

Response: We would like to thank the reviewers for their comments; additional explanations have been included in the manuscript.

Revised: Lines 291 to 293:

~~By comparison, neural networks exhibit superior capability in processing nonlinear data.~~ By comparison, machine learning methods, including neural networks, random forests, Gaussian processes, and support vector machines, have demonstrated strong capability in processing nonlinear data and capturing complex interactions among variables.

Comment 2: Second, two reviewers raised concerns regarding overfitting and potentially inflated performance metrics. While the authors responded adequately to these concerns, the discussion provided in their response was not incorporated into the manuscript itself. I think it would strengthen the manuscript if a few sentences addressing overfitting mitigation were added directly to the text.

Response: We thank the reviewers for their comments; an explanation regarding neural networks has been added to the manuscript.

Revision:

(1) Lines 309 to 314:

~~After extensive comparative tests, the number of neurons in the hidden layer was determined to be 10~~. Although a more complex hidden layer architecture could substantially improve the prediction accuracy on the training data, it would also introduce a higher risk of overfitting and degrade generalization performance. Therefore, in this study, the hidden layer structure was simplified as much as possible while ensuring that the network retained adequate predictive capability; after extensive comparative tests, a single hidden layer with 10 neurons was ultimately adopted, striking a balance between prediction accuracy and generalization performance.

(2) Lines 366 to 368:

In summary, although the predictive performance on the test set is slightly lower than that on the training set, the degradation is limited and the test set accuracy remains at a satisfactory level. This indicates that the neural network model does not suffer from severe overfitting and possesses adequate generalization ability for practical application.

Comment 3: Finally, I have one technical comment regarding Figure 24. The figure no longer appears to be cited in the manuscript, and I feel it could be removed.

Response: Thank you for the reviewers' comments. Figure 24 has been removed from the manuscript.

Supplement to Table 4

Revised: Lines 375 to 391:

4.2.3 Prediction of Shear Strength Parameters

Based on the GA-BP neural network model, shear strength was predicted for various combinations of density (300 to 650 kg·m^{-3}), sintering time (0 to 60 days), sintering temperature (-5 to -25 °C), and normal stresses of 25 kPa, 50 kPa, 75 kPa, and 100 kPa, at a fixed shear rate of 0.8 mm·min^{-1}. These predicted values were used to derive the corresponding cohesion and internal friction angle, with the results summarized in Table 4.

Table 4 Compacted snow shear strength parameters (25 to 100 kPa normal stress, shear rate v=0.8mm·min^{-1})

ρ	T_s	t=1d		t=5d		t=10d		t=15d		t=30d		t=60d	
(kg·m^{-3})	(°C)	c(kPa)	φ(°)	c(kPa)	φ(°)	c(kPa)	φ(°)	c(kPa)	φ(°)	c(kPa)	φ(°)	c(kPa)	φ(°)
300	-5	30.16	16.23	34.15	15.35	36.79	13.58	35.50	12.41	34.78	11.30	26.87	10.69
	-10	25.02	17.53	33.89	16.70	34.77	14.91	34.20	13.58	32.21	11.53	22.05	10.99
	-15	24.35	19.32	33.11	18.37	34.94	15.22	33.10	13.87	28.50	12.18	19.24	11.66
	-20	24.16	20.90	31.29	19.69	32.28	15.38	28.10	14.61	25.68	13.18	18.98	12.92
	-25	18.23	21.76	23.41	21.09	30.47	17.21	25.43	16.86	20.69	15.93	13.94	14.29
350	-5	32.74	20.61	52.36	20.10	55.73	17.69	60.83	16.50	61.61	15.96	45.51	14.02
	-10	30.36	21.17	46.28	22.62	52.62	18.62	52.14	17.86	48.10	16.88	33.79	15.77
	-15	30.02	24.15	41.20	22.93	42.09	20.00	40.40	22.11	33.67	21.80	28.74	20.48
	-20	30.51	24.37	34.81	25.88	41.94	25.66	38.98	23.46	28.67	22.07	26.01	21.20
	-25	28.34	26.39	32.43	26.48	39.76	25.76	37.41	24.90	26.05	22.30	21.17	21.60
400	-5	42.25	28.33	65.30	26.61	75.89	25.48	66.52	23.55	65.64	18.81	52.18	17.25
	-10	46.69	30.83	63.24	27.10	67.05	26.81	54.26	25.55	52.32	24.24	46.23	21.23
	-15	43.83	31.74	54.61	28.52	51.59	28.04	46.95	27.57	47.93	25.31	38.68	22.38
	-20	32.47	32.36	41.27	30.74	47.22	29.03	45.03	28.26	40.48	27.77	32.65	23.49
	-25	30.50	33.67	39.83	33.14	46.33	31.94	40.61	31.13	30.59	29.44	26.55	28.41
450	-5	57.87	40.24	77.97	37.10	90.77	30.90	99.63	29.82	102.92	28.97	83.80	21.96
	-10	56.08	40.86	82.47	37.55	89.36	33.13	90.41	31.34	85.72	29.83	72.50	24.72
	-15	55.78	41.83	78.79	38.98	81.05	38.20	80.87	36.17	76.00	30.13	67.91	26.53
	-20	54.65	41.26	77.85	39.04	80.48	38.46	74.92	37.84	70.15	32.12	64.00	30.90
	-25	53.55	42.85	74.80	40.98	77.00	39.48	69.98	38.04	65.06	36.67	61.82	34.05
500	-5	84.44	44.83	107.94	44.01	128.50	42.42	135.93	38.01	121.49	36.36	108.92	32.30
	-10	81.45	47.82	101.51	46.09	118.30	45.19	122.38	40.39	112.09	39.11	98.68	36.19

Table 4 Compacted snow shear strength parameters (25 to 100 kPa normal stress, shear rate v=0.8mm·min^{-1})

(continued)

ρ	T_s	t=1d		t=5d		t=10d		t=15d		t=30d		t=60d	
(kg·m^{-3})	(℃)	c(kPa)	φ(°)	c(kPa)	φ(°)	c(kPa)	φ(°)	c(kPa)	φ(°)	c(kPa)	φ(°)	c(kPa)	φ(°)
500	-15	73.55	50.40	95.53	48.38	111.06	47.07	109.39	44.18	110.45	40.94	97.20	36.19
	-20	72.12	51.50	91.18	49.93	103.05	48.47	101.81	45.51	99.13	41.48	89.23	36.15
	-25	67.39	52.43	84.13	51.32	96.70	48.90	97.80	46.79	89.56	43.41	87.17	38.78
550	-5	109.40	48.82	132.91	47.02	150.11	44.14	160.57	42.62	147.66	42.52	137.11	33.51
	-10	109.79	51.90	132.26	49.82	149.29	47.29	151.61	45.08	138.36	45.26	132.29	38.06
	-15	107.32	53.08	126.85	50.96	142.04	49.30	136.39	47.45	121.27	48.70	118.46	40.70
	-20	101.38	54.05	116.68	50.74	128.30	50.50	125.78	48.82	119.58	48.70	116.62	41.75
	-25	92.07	54.69	106.02	52.30	120.63	50.05	114.43	50.63	107.89	48.70	101.46	41.89
600	-5	128.87	54.74	143.23	54.37	157.11	52.70	165.06	50.83	155.70	45.23	142.78	39.50
	-10	124.06	56.32	138.30	55.33	154.60	53.05	156.90	51.73	146.94	46.15	136.44	40.33
	-15	107.03	57.33	126.05	56.65	144.32	53.51	154.95	52.61	143.54	49.32	126.97	41.19
	-20	99.75	57.56	121.08	56.93	140.21	54.66	149.13	53.87	139.17	49.11	121.45	43.19
	-25	96.69	58.22	118.01	57.89	137.25	56.84	145.38	55.57	132.08	51.15	119.93	46.19
650	-5	140.52	58.71	159.95	58.49	167.41	56.81	167.67	55.51	160.17	47.30	149.92	44.49
	-10	134.57	61.25	158.24	59.85	163.46	57.74	161.40	56.97	154.92	48.78	142.25	46.70
	-15	135.22	61.25	158.04	58.17	161.49	58.04	159.72	57.51	152.07	49.47	140.56	47.70
	-20	137.67	61.34	157.24	59.11	160.84	58.26	158.54	58.28	151.68	50.70	138.87	48.70
	-25	139.94	62.15	154.22	60.81	157.57	59.15	156.51	58.63	149.99	52.70	127.08	48.73