XXIII. Experiments on the strength of different kinds of woods; made in the Carriage Department, Royal Arsenal, Woolwich

Mr. Peter Barlow Jun.

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Experiments on the Strength of Woods, by Mr. Barlow, Jun. 179

$$\varrho \sin p = [0.56697] \sin (E' + 166^\circ 59' 24'') - 0.28859$$

$$\varrho \cos p = [0.65768] \sin (E' + 298^\circ 18' 42'') + 1.39075,$$

and the agreement of the orbit with these observations may be seen from the following ephemeris :

1779.77	0° 0'	4.56	1824.0	295° 9'	3.42
1781.74	5 56	4.18	4.5	297 29	3.61
1802.34	118 39	3.86	1825.0	299 34	3.80
1804.42	126 14	4.06	5.5	301 28	3.98
1818.0	222 33	1.68	1826.0	303 12	4.16
1818.5	232 41	1.69	6.5	304 47	4.33
1819.0	242 30	1.74	1827.0	306 15	4.50
1819.5	251 34	1.83	7.5	307 37	4.66
1820.0	259 39	1.95	1828.0	308 54	4.82
1820.5	266 42	2.10	8.5	310 6	4.97
1821.0	272 45	2.26	1829.0	311 14	5.11
1821.5	277 56	2.44	9.5	312 18	5.24
1822.0	282 24	2.63	1830.0	313 19	5.37
1822.5	286 15	2.83	0.5	314 17	5.50
1823.0	289 36	3.02	1831.0	315 13	5.61
1823.5	292 33	3.22			

The following Table exhibits its comparison with Struve's observations :

	Calculated.		Differences.	
	301° 39'	4.00	0	0.00
1825.55	301° 39'	4.00	0	0.00
1826.8	305 41	4.43	+ 125	+ 0.09
1827.4	307 21	4.63	+ 75	+ 0.12
1828.75	310 41	5.04	+ 53	+ 0.25
1829.4	312 5	5.21	+ 32	+ 0.03

The total discrepancy between the orbit and the observations of the years 1818–1823, proves that if this system obeys the law which we have assumed, the great diminution of the distance of 1825, in comparison with that of 1830, cannot have taken place.

[To be continued.]

XXIII. *Experiments on the Strength of different Kinds of Woods ; made in the Carriage Department, Royal Arsenal, Woolwich. By Mr. PETER BARLOW, Jun. As. Inst. Civ. Eng.**

THE following series of experiments, several of which I attended, being made on species of woods, the strength of which has not been previously ascertained, will I trust not

* Communicated by the Author.

be considered uninteresting to the readers of the *Phil. Mag. and Annals*; particularly as the results are not only curious, but may probably lead to useful and important investigations, as connected with the introduction into and the growth of foreign timber in this country, as well as to important improvements in the present system of planting. Under this impression I have been induced to send them to you as an addition to the several others on the same subject which have appeared at different times in this Journal.

The experiments originated in an investigation of the comparative properties of acacia and oak by W. Withers, Esq. of Norfolk, whose object appears to have been to encourage the planting of the former in many situations instead of the latter, as a wood of great durability, and of quicker growth. In order to have a comparison made of their relative strengths, he forwarded specimens of both woods to Woolwich, and the results of the experiments will be seen in the following Table.

Another question arose with Mr. Withers relative to the strength of oak, the growth of which had been encouraged by culture, compared with oak of the ordinary slow growth*. The specimens connected with the latter subject, the author informs us, were received from Mr. W. Boorne of Erpingham; the one from a fast and the other from a slow growing tree. They are marked Nos. 3 and 4 in the Table of Experiments. The former was grown on a very good strong soil, its age was supposed about 60 years, and it contained from 38 to 40 cubic feet of timber: the other, No. 4, was about 120 years old, and was grown upon light soil, with gravel about 2 feet below the surface. This tree contained about 80 cubic feet, but Mr. Boorne considers that if No. 3 had stood to attain the same age, it would have made at least 40 feet more than that tree. The other two specimens were from trees furnished by Mr. Samuel Farrow of Diss, Norfolk, grown on the same piece of land: that from which No. 5 was cut, stood near the rack-yard of the farm by the side of a ditch, into which ran a great deal of moisture from the yard; and he has no doubt that, independently of the nourishment obtained by it from the ditch, very many of the smaller roots reached as far as the rack-yard; and the tree grew rapidly, and contained when cut down 120 feet of timber. The tree from which No. 6 was cut, grew, as before stated, in the same field, but had none of the advantages above spoken of; but still the soil was good, with a lightish blue clay bottom. The tree grew well, but not in any degree so fast as the other: it contained about 90 feet of

* See a Letter to Sir Henry Stewart, Bart. on the improvement in the quality of timber, by W. Withers, Esq.

timber,

timber, and it is the opinion of persons on the spot that they were both planted together.

Thus far the experiments were made with a particular object; but as there were in store, in the Royal Arsenal, many woods, not in very common use, but which are grown abundantly in some countries, and from the appearance of which great strength was anticipated, Mr. Bossey, foreman in the carriage department, was requested to prepare specimens, which were submitted to the same test as the former ones.

These results are interesting, some of the woods being more than double the average strength of oak: several of these specimens were sent from Berbice by Capt. Gipps of the Royal Engineers, who speaks very highly of their durability.

The apparatus made use of in the experiments consisted simply of two upright posts, fixed securely at one end in the ground, and at the other to the tie beam of the roof of a shed; on each of these were firmly attached two pieces of hard wood formed to an edge, on which the specimens to be experimented upon were placed, and a scale suspended from the centre to receive weights. To ascertain the relative stiffness or elasticity, the weight which caused a deflection of one inch, was registered, which was denoted by a rod attached to the tie beam so as to point downwards in front of the middle of the specimen, and one inch below the upper surface; so that when one inch of deflection had taken place, it was shown by the rod just passing clear of the piece under experiment.

In the Table, the 1st column contains the names of the woods; the 2nd the specific gravity; the 3rd the weight which caused 1 inch deflection, or $\frac{1}{30}$ th part of the length; the 4th, the breaking weight; the 5th, the relative elasticity from the formula $E = \frac{l^3 w}{a d^3 \delta}$; the 6th, the strength from the formula

$S = \frac{l w}{4 a d^3}$; where l is the length, a the breadth, d the depth, δ the deflection in inches, and w the weight in pounds; by which they become comparative with the various experiments in Barlow's Essay on the Strength of Timber; and the last column contains any requisite description or remarks.

The pieces were each accurately cut and planed 2 inches square, and 5 feet in length; and the distance of the props on which they were broken was exactly 50 inches: they were selected with great care by Mr. Bossey, who assisted at the experiments, and registered and delivered the following results.

Table

Table of the Strength and Elasticity of various Woods of English and Foreign Growth.

No. of Experiments.	Names of Wood.	Specific Gravity.	Weight in lbs. which produced 1 inch deflection.	Breaking Weight, in lbs.	Value of E from the formula $E = \frac{P \cdot L}{A \cdot \Delta l}$.	Value of S from the formula $S = \frac{P}{A}$.	Remarks.
1	Acacia, English growth	710		1195		1867	} piecelittle injured. Specimens supplied by W. Withers, Esq.
2	— Ditto.	710	bore	1084	rope broke,	e, the	
3	Oak, fast grown	903	660	999	5156250	1561	
4	— slow grown	856	414	677	3234375	1058	
5	— fast grown	972	550	999	4296875	1561	
6	— slow grown ...	835	439	943	3437500	1473	
7	— superior quality	748	896	1447	7000000	2261	} Very fine specimens; been in store two years.
8	— ditto	756	680	1304	5312500	2037	
9	Tonquin { middle	1036	1388	2414	10843750	3850	} This timber was sent from Berbice by Capt. Gipps, R. E.
10	Bean { outside	1080	1332	2228	10406250	3481	
11	Locust... { middle	972	1052	2116	8007812	3303	
12	— { outside	936	940	2284	7343750	3568	
13	Bullet Tree.. { middle	1029	1360	1724	10625000	2696	
14	— { outside	1029	1332	1668	10406250	2606	
15	Greenheart... { middle	1015	1332	1892	10406250	2956	
16	— { outside	986	1388	1612	10843750	2562	
17	Cabacally... { middle	907	952	1668	7437500	2606	
18	— { outside	892	940	1556	7343750	2431	
19	— { middle	972	1168	1447	9132812	2261	
20	African Oak. { outside	972	1168	1657	9125000	2589	
21	— { middle	1015	1288	1643	10062500	2567	} From a very fine timber long in store.
22	— { outside	972	1097	1643	8570312	2567	
23	— { middle	648	775	1279	6054687	1967	} A long time in store, very dry; the same tree.
24	American { outside	633	775	915	6054687	1430	
25	Black Birch { middle	648	644	1027	5031250	1604	
26	— { outside	669	831	1433	6492187	2239	} Dry, and of the same plank.
27	Common { middle	792	800	1164	6250000	1820	
28	Birch... { outside	630	884	1304	6908250	2037	
29	— { middle	727	660	1304	5156250	2037	
30	Ash... { outside	702	660	1304	5156250	2037	
31	— { middle	554	436	772	3406250	1206	} Dry, and of the same tree.
32	Elm... { outside	532	324	660	2531250	1031	
33	Christiana { middle	698	856	1052	6687500	1644	} Dry, and of the same deal.
34	Deal... { outside	680	772	940	6031250	1480	
35	Memel Deal { middle	590	786	1108	6140625	1731	} Dry, and of the same deal.
36	— { outside	590	856	1108	6687500	1731	

It is to be regretted that the results of the acacia were not more particularly noted; but not having in view at that time to carry on so extensive a course of experiments, means were not taken to ascertain its stiffness. The second specimen, after the rope broke, was found but little injured by the experiment, which certainly indicates considerable power of elasticity,

city, although the exact amount was not numerically ascertained. This specimen was preserved unbroken. Upon the whole, however, it has the advantage of the oaks in strength, except those marked No. 7 and 8, which were remarkably fine specimens; but it will be found by referring to Barlow's *Essay* to greatly exceed the strength of oak in general.

The results of the oak experiments seem certainly to be in favour of the fast grown. "These experiments," Mr. Withers observes, "throw new light upon the subject, and lead to the most important conclusions. They prove not only that fast growing timber is superior in quality to that of slower growth, but that by the constant application of manure to the roots of trees planted even in good soil, nearly double the quantity of timber may be obtained in the same period, while its strength instead of being diminished will be thereby increased."

XXIV. *Papers relating to a Design for the New London Bridge, on the Principle of Cementitious Architecture:—exhibited to the Committee of the House of Commons, on the 11th of April 1823. By JOHN WHITE, Esq.**

[With a Plate.]

CONTENTS.—Mr. White's Letter to the Comptroller of the Estates of London Bridge.—Mr. Newman to Mr. White.—Mr. White to Dr. Gregory.—General Observations on the Designs for London Bridge.—Dr. Gregory's Reply.—Dr. Gregory's Observations.—Mr. White to the Editor of the Quarterly Journal.—Account of Experiments on Cements.—Inference from these Experiments.—Extract from the Memoirs of Savary, Duke of Rovigo.

I. *To the Comptroller of the Estates of London Bridge.*

Sir,—

I BEG leave to submit to your notice the following suggestions upon the subject of the removal of London Bridge, to which the mind of the public is at the present time so much directed, premising that I agree with the Second Report of the Committee of the House of Commons, that a work of such public importance as the plan of 1814 should not be undertaken without the greatest and most unequivocal certainty of ultimate success, and that it is, as the Committee conceived, extremely doubtful whether a New Bridge would not ultimately be found less expensive than the proposed alteration.

The River Thames is considered as a river having an artificial obstacle, producing a rapid and extremely irregular fall

* Communicated by the Author.—Mr. Telford's Report, in 1823, on the effects on the Thames of rebuilding London Bridge, and another paper on the same subject, will be found in *Phil. Mag.* vol. lxii. p. 21, 28.