International Journal of Innovation Scientific Research and Review
Vol. 06, Issue, 09, pp.6994-6999, September 2024
Available online at http://www.journalijisr.com
SJIF Impact Factor 2023: 6.599

IJISRR

ISSN: 2582-6131

Research Article

ENHANCING QUALITY ASSURANCE IN PAPER PRODUCTION: AN INTER-LABORATORY COMPARISON OF TESTING PARAMETERS FOR 80 GSM SS MAPLITHO PAPER

[1,] * Shwet Vashishtha, [2]S.P. Kalia, [1]D. Sarkar, [1]Pankaj Jhan, [1]Sarvendra Singh, [1]Ayan Kumar

[1]R.P.P.T. Laboratory, National Test House, Ghaziabad, India.
[2]R.P.P.T. Laboratory, National Test House, Mumbai, India.

Received 21st July 2024; Accepted 22th August 2024; Published online 30th September 2024

ABSTRACT

Inter Laboratory Comparisons (ILC) play a crucial role in ensuring accuracy, precision, and standardization of measurements across different laboratories. In this study, an ILC was conducted on 80 GSM SS Map litho paper to evaluate key physical and chemical parameters across 15 laboratories. This investigation was carried out in adherence to the Indian Standard IS 1060 guidelines, focusing on 12 critical paper testing parameters: Substance (Grammage), Thickness, Tensile Index, Tear Index, Brightness (ISO), Opacity, One Minute Cobb, Double Fold, Smoothness (Bendsten), pH, Moisture Content, and Ash Content. The purpose of this ILC was to identify variability in test outcomes across different laboratories and to assess their conformity to established standards. Each parameter measured in this program holds significant value in determining the quality and performance characteristics of the paper. For instance, grammage and thickness directly affect the handling and printing quality, while tensile and tear indices reflect the strength and durability of the paper. Additionally, properties such as brightness, opacity, and smoothness influence the visual and tactile attributes, which are essential for end-users in the printing and packaging industries. Results revealed that while most laboratories showed satisfactory agreement with the reference values, minor deviations were observed in parameters like tensile index, tear index, and Cobb test. Such deviations could stem from differences in equipment calibration, operator skill, or environmental factors like humidity during testing. By highlighting these discrepancies, the ILC underscores the need for consistent calibration procedures and harmonized testing conditions to ensure uniformity in results. This ILC also emphasizes the importance of continuous participation in such proficiency testing programs to maintain and improve laboratory performance. Regular ILCs provide valuable feedback for laboratories, helping them identify areas of improvement, adopt best practices, and ensure compliance with international testing standards. In conclusion, this study demonstrates the efficacy of ILC in benchmarking laboratory capabilities and ensuring the reliability of test results. The results obtained from this exercise contribute to the broader goal of quality assurance in the paper manufacturing and testing industries, fostering trust among stakeholders and maintaining consistency in paper quality. Future studies could focus on expanding the scope of testing to include additional paper grades and explore the integration of advanced analytical tools for even greater accuracy in parameter measurement.

Keywords: Maplitho Paper, Tensile Index, Tear Index, Brightness, Opacity, Moisture Content, Ash Content.

INTRODUCTION

Inter Laboratory Comparison (ILC) programs have emerged as an essential tool for assessing and improving the reliability and accuracy of testing across multiple laboratories. By comparing results from different laboratories that use the same testing procedures, these programs identify discrepancies, ensure consistency, and validate measurement processes. ILCs are fundamental in quality control and accreditation programs, especially in industries where precision is critical. One such industry is the paper manufacturing and testing industry, where even minor deviations in test results can significantly impact product quality, performance, and usability.

Importance of ILC in Paper Testing:

Paper is a ubiquitous material, used in industries ranging from publishing to packaging. Given its diverse applications, ensuring the quality and uniformity of paper products is critical. ILC programs play a pivotal role in benchmarking laboratory testing capabilities in this domain. The main objective of such programs is to assess whether the results from different laboratories align with standardized values. For paper testing, parameters such as Substance (Grammage), Thickness, Tensile Index, Tear Index, Brightness (ISO), Opacity, One Minute Cobb, Double Fold, Smoothness (Bendsten), pH, Moisture Content, and Ash Content are commonly evaluated [1-12]. These properties not only determine the paper's strength and durability but also its aesthetic qualities like brightness and opacity, which are important for specific applications such as printing and packaging.

Overview of ILC on 80 GSM SS Maplitho Paper

In this research, an ILC program was conducted on 80 GSM SS Maplitho paper, a widely used paper type in the printing industry. A total of 15 laboratories participated in the study, where each lab tested the 12 aforementioned parameters following the guidelines laid out by IS 1060. The IS 1060 standard is recognized for specifying methods for sampling and testing various types of paper. Its use ensures that laboratories follow a consistent methodology, minimizing discrepancies arising from differing techniques or interpretations.

The primary aim of this ILC was to evaluate the inter-laboratory variability in the results of these 12 test parameters. Identifying any inconsistencies across labs allows for a deeper understanding of the precision of the methodologies employed. It also provides an opportunity for labs to improve their testing processes by aligning them more closely with the standard. The ability of laboratories to produce accurate and reproducible results is essential for ensuring quality control within the paper industry.

Parameters Tested and Their Significance

a) Substance (Grammage): This parameter defines the mass per unit area of the paper, usually expressed in grams per square meter (GSM). It is one of the most fundamental characteristics,

***Corresponding Author: Shwet Vashishtha,**
1R.P.P.T. Laboratory, National Test House, Ghaziabad, India.

influencing both the handling of the paper and its suitability for specific applications [1].

b) Thickness: Thickness affects the stiffness, opacity, and overall feel of the paper. Uniformity in thickness ensures consistency in handling, printing, and packaging [2].
c) Tensile Index & Tear Index: These parameters measure the strength of the paper. The tensile index indicates the maximum force the paper can withstand before breaking, while the tear index reflects the paper's resistance to tearing [3-4].
d) Brightness and Opacity: These optical properties affect the paper's appearance and its performance in printing applications. Brightness refers to the reflectance of the paper, while opacity measures the degree to which the paper can block light transmission [5-6].
e) One Minute Cobb Test: This test evaluates the paper's ability to absorb water over a set period. It is crucial in determining how paper will perform when exposed to moisture, particularly in packaging applications [7].
f) Double Fold: This parameter assesses the durability of the paper by measuring the number of folds it can endure before breaking. It is especially relevant for papers used in books or documents subject to repeated handling [8].
g) Smoothness: Smoothness affects print quality and tactile feel. High smoothness is essential for applications like high-quality printing, where sharp image reproduction is required [9].
h) pH: The pH level of paper affects its longevity and interaction with inks and other chemicals. Acidic papers may degrade faster, which is why pH-neutral or alkaline papers are preferred for archival purposes [10].
i) Moisture Content: Moisture content impacts both the physical strength and dimensional stability of the paper. Excess moisture can cause the paper to curl or warp, while too little can make it brittle [11].
j) Ash Content: Ash content gives insight into the mineral filler used in the paper, which can affect its brightness, smoothness, and printability [12].

Challenges and Insights from the ILC Study:

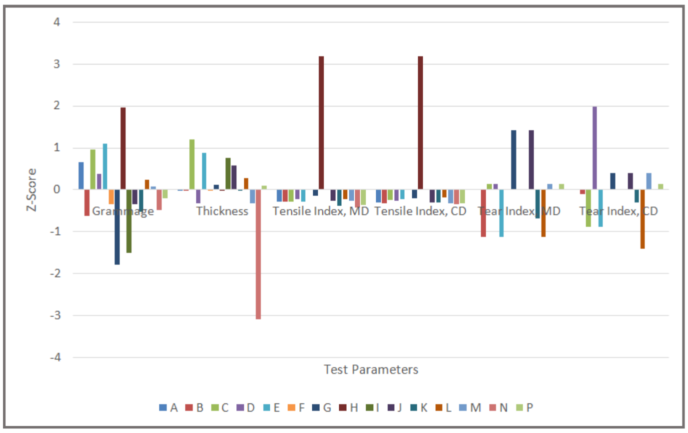

Fig. 1: Bar Chart showing the Z-Score against the test parameters

While the majority of participating laboratories demonstrated acceptable conformity to the reference standards, deviations in certain parameters were observed. Variations in tensile and tear indices, Cobb test results, and smoothness were especially prominent. These deviations likely stem from factors such as differences in equipment calibration, operator expertise, and environmental conditions during testing. This highlights the importance of maintaining stringent calibration protocols and ensuring consistency in testing environments across laboratories.

Additionally, the findings of this study suggest that participation in ILC programs significantly contributes to improving laboratory performance. By identifying inconsistencies and providing feedback, laboratories can address gaps in their procedures, enhancing overall testing quality and reliability. Continuous involvement in such programs is crucial for sustaining high standards of quality assurance in the paper industry. This study underscores the critical role of ILC programs in maintaining high testing standards in the paper industry. The results of this research contribute to the ongoing efforts to ensure the accuracy and reliability of paper testing methodologies. By fostering a culture of continuous improvement and adherence to standardized procedures, ILC programs help laboratories enhance their performance and guarantee the consistent quality of paper products in the market.

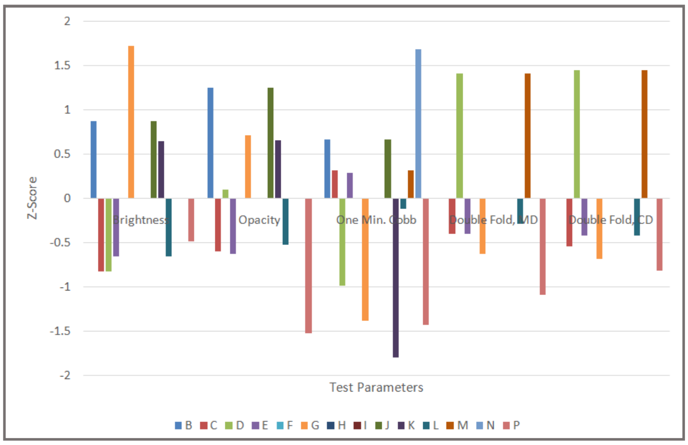

Fig. 2: Bar Chart showing the Z-Score against the test parameters

OBJECTIVE

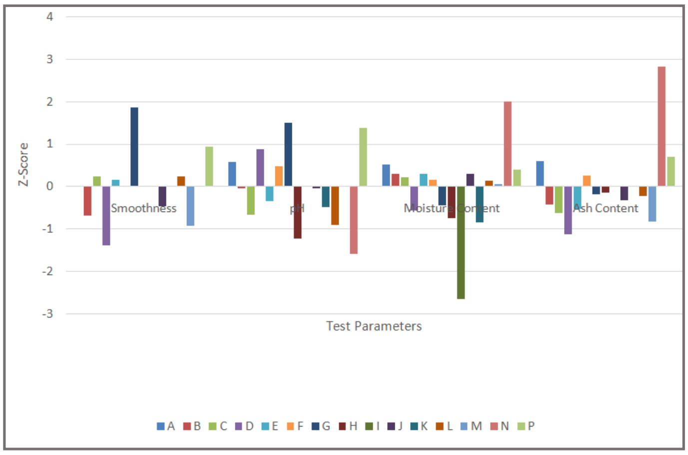

Fig. 3: Bar Chart showing the Z-Score against the test parameters

The primary objective of the **Inter-Laboratory Comparison (ILC)** program in this research was to assess and validate the performance of 15 participating laboratories in the testing of **80 GSM SS Maplitho paper**. This was achieved by comparing the precision, reproducibility, and accuracy of test results across multiple laboratories for 12 critical parameters. Specifically, the study aimed to:

a) Evaluate the consistency of results across different laboratories.
b) Identify potential discrepancies and their sources.
c) Provide a benchmark for continuous improvement in paper testing procedures.
d) Contribute to the standardization of paper quality testing methodologies as per IS 1060 standards.

DESIGN OF THE SCHEME

The design of the ILC followed a round-robin testing approach, where identical samples of 80 GSM Maplitho paper were distributed to all participating laboratories. The ILC was structured as follows:

a) Sample Preparation: Identical batches of 80 GSM SS Maplitho paper were prepared and distributed to each laboratory. Each sample was handled according to standard procedures to ensure no damage or contamination occurred.
b) Parameter Testing: Laboratories were instructed to test the samples on the following 12
c) Data Collection: Each laboratory was required to submit their test results for the 12 parameters, along with details of the testing conditions and equipment used.
d) Data Analysis: The results were compiled and statistically analyzed for consistency and reproducibility. Common metrics such as the z-score and coefficient of variation were used to evaluate performance.
e) Report and Feedback: The final comparison report was generated, highlighting any outliers, performance issues, or deviations from the expected results. Feedback was provided to each laboratory to improve future testing performance.

MATERIALS AND METHODS

Materials:

The study was conducted using 80 GSM SS Maplitho paper, which is a standard grade of paper used in printing and publishing industries. The paper used for the tests adhered to the Indian Standard IS 1060, which governs the quality control and testing of paper products. The Maplitho paper selected for the study had the following characteristics:

a) Substance: 80 GSM (Grams per Square Meter)
b) Type: SS (Superfine Surface) Maplitho
c) **Source:** The paper samples were procured from 15 different laboratories participating in the Inter Laboratory Comparison (ILC) program. Each lab followed standard procedures for handling and storing paper to avoid moisture contamination or physical damage.

Methods:

The methodology for testing the Maplitho paper involved 12 critical parameters, each of which was tested according to IS 1060 standards:

a) Substance (Grammage): The mass per unit area was measured using a precision electronic balance and standardized templates for sample cutting. The result was expressed in GSM.
b) Thickness: The thickness of the paper was measured using a paper thickness gauge with an accuracy of ±1 micron. Five readings were taken for each sample, and the average was recorded.
c) Tensile Index: The tensile strength of the paper was evaluated using a tensile testing machine. The paper was subjected to a controlled pulling force until it tore, and the tensile index was calculated as the force per unit area.
d) Tear Index: A tear resistance tester was used to measure the force required to tear the paper. The results were expressed in terms of the tear index.
e) Brightness: Brightness was determined using a photometer, which measured the percentage of light reflected by the paper surface under standardized illumination conditions.
f) Opacity: A reflectance meter was used to measure the opacity of the paper. Opacity is the degree to which the paper prevents the transmission of light.
g) One Minute Cobb: The water absorption capacity of the paper was tested using the Cobb sizing tester. The paper sample was exposed to water for one minute, and the amount of water absorbed was measured.
h) Double Fold: The folding endurance of the paper was tested by repeatedly folding a sample until it broke. The number of folds before breaking was recorded as the Double Fold value.
i) Smoothness: The smoothness of the paper was measured using a smoothness tester. The smoother the paper, the lower the air leakage through its surface.
j) pH Measurement: A pH meter was used to determine the acidity or alkalinity of the paper.
k) Moisture Content: The moisture content was determined using a moisture analyzer, which recorded the percentage of water present in the paper.
l) Ash Content: Ash content was determined by incinerating the paper sample in a muffle furnace at 900°C and measuring the remaining inorganic residue.

The 15 participating laboratories conducted tests using identical paper samples and procedures. Each lab was provided with clear instructions and followed the IS 1060 guidelines to ensure uniformity. After conducting the tests, the results from all laboratories were compiled, analyzed, and compared to assess inter-laboratory variability and identify any significant deviations from the expected values.

The data was subjected to statistical analysis to evaluate the precision and reproducibility of each laboratory's results. Parameters such as standard deviation, coefficient of variation, and z-scores were calculated to compare the performance of the laboratories.

RESULTS AND DISCUSSION

The Inter-Laboratory Comparison (ILC) of 80 GSM SS Maplitho paper (Table 1a, Table 1b, and Table 1c) focused on testing multiple parameters across various labs. These parameters, including Brightness, Opacity, Cobb value, Double Fold (MD and CD), Smoothness, pH, Moisture Content, and Ash Content, were assessed for reproducibility and consistency through Z-scores. The Z-scores in Table-1 indicate how each lab's results deviated from the consensus values.

Brightness and Opacity:

Brightness ranged from 83.0% to 84.5%, with Lab G showing the highest brightness (84.5%) and the highest Z-score (1.73), indicating excellent performance. Lab C scored lower with a Z-score of -0.83. Most labs were close to the average, signifying good reproducibility.

Opacity values varied from 86.1% to 98.2%, with Lab P showing the lowest value and a Z-score of -1.53. Lab J had the highest value with a Z-score of 1.25, implying accurate opacity measurements for high-performing labs.

Cobb and Double Fold:

Cobb values were relatively consistent across labs, ranging from 24.2 to 30.0 g/m². Labs B and J had similar Cobb values (30.0), with Z-scores around 0.67. In the Double Fold test, Lab D had the highest results in both MD (40) and CD (31), supported by Z-scores of 1.41 and 1.45, respectively. This indicates superior folding endurance compared to other labs, like Lab P, which had much lower Double Fold values.

Table 1(a): Lab Results and corresponding Z-Scores

Participant Lab Code	Grammage (GSM)		Thickness (microns)		Tensile Index, MD (Nm.g)		Tensile Index, CD (Nm.g)		Tear Index, MD (mN.m2/g)		Tear Index, CD (mN.m2/g)	
	Lab Result	Z-Score	Lab Result	Z-Score	Lab Result	Z-Score	Lab Result	Z-Score	Lab Result	Z-Score	Lab Result	Z-Score
A	81.9	0.66	100.0	-0.03	38.1	-0.29	22.2	-0.32	-	-	-	-
B	81.0	-0.64	100.0	-0.03	38.0	-0.29	22.0	-0.33	3.8	-1.14	4.8	-0.12
C	82.1	0.95	104.0	1.19	37.7	-0.30	23.8	-0.25	3.9	0.14	4.5	-0.90
D	81.7	0.37	99.0	-0.34	40.0	-0.24	23.0	-0.28	3.9	0.14	5.6	1.97
E	82.2	1.09	103.0	0.88	37.7	-0.30	24.0	-0.24	3.8	-1.14	4.5	-0.90
F	81.2	-0.35	100.0	-0.03	-	-	-	-	-	-	-	-
G	80.2	-1.79	100.5	0.12	43.9	-0.15	24.7	-0.21	4.0	1.42	5.0	0.40
H	82.8	1.96	100.0	-0.03	183.2	3.17	105.5	3.17	-	-	-	-
I	80.4	-1.51	102.6	0.76	-	-	-	-	-	-	-	-
J	81.2	-0.35	102.0	0.58	38.4	-0.28	22.2	-0.32	4.0	1.42	5.0	0.40
K	81.1	-0.54	100.0	-0.03	32.5	-0.40	21.8	-0.32	3.8	-0.70	4.7	-0.31
L	81.6	0.23	101.0	0.27	40.3	-0.24	24.9	-0.20	3.8	-1.14	4.3	-1.42
M	81.5	0.08	99.0	-0.34	39.0	-0.27	22.0	-0.33	3.9	0.14	5.0	0.40
N	81.1	-0.50	90.0	-3.09	31.7	-0.44	21.1	-0.36	-	-	-	-
P	81.3	-0.21	100.4	0.09	34.2	-0.38	22.0	-0.33	3.9	0.14	4.9	0.14

Table 1(b): Lab Results and corresponding Z-Scores

Participant Lab Code	Brightness (%)		Opacity (%)		One Min. Cobb g/m2		Double Fold, MD (Nos.)		Double Fold, CD (Nos.)		Smoothness (ml/min)	
	Lab Result	Z-Score	Lab Result	Z-Score	Lab Result	Z-Score	Lab Result	Z-Score	Lab Result	Z-Score	Lab Result	Z-Score
A	-	-	-	-	-	-	-	-	-	-	-	-
B	84.0	0.87	98.0	1.25	30.0	0.67	-	-	-	-	120	-0.69
C	83.0	-0.83	90.0	-0.60	29.0	0.31	24	-0.41	16	-0.55	140	0.24
D	83.0	-0.83	93.0	0.09	25.4	-0.99	40	1.41	31	1.45	105	-1.39
E	83.1	-0.66	89.9	-0.63	28.9	0.28	24	-0.41	17	-0.42	138	0.15
F	-	-	-	-	-	-	-	-	-	-	-	-
G	84.5	1.73	95.7	0.71	24.3	-1.39	22	-0.63	15	-0.69	175	1.87
H	-	-	-	-	-	-	-	-	-	-	-	-
I	-	-	-	-	-	-	-	-	-	-	-	-
J	84.0	0.87	98.2	1.25	30.0	0.67	-	-	-	-	125	-0.46
K	83.9	0.65	95.7	0.66	21.7	-1.80	-	-	-	-	-	-
L	83.1	-0.66	90.3	-0.53	27.8	-0.12	25	-0.29	17	-0.42	140	0.24
M	-	-	-	-	29.0	0.31	40	1.41	31	1.45	115	-0.92
N	-	-	-	-	32.8	1.69	-	-	-	-	-	-
P	83.2	-0.49	86.1	-1.53	24.2	-1.43	18	-1.09	14	-0.82	155	0.94

Table 1(c): Lab Results and corresponding Z-Scores

Participant Lab Code	pH		Moisture Content (%)		Ash Content (%)	
	Lab Result	Z-Score	Lab Result	Z-Score	Lab Result	Z-Score
A	8.10	0.58	5.60	0.53	14.90	0.60
B	7.90	-0.04	5.30	0.30	13.90	-0.42
C	7.70	-0.67	5.20	0.22	13.70	-0.62
D	8.20	0.89	4.20	-0.56	13.20	-1.13
E	7.80	-0.35	5.30	0.30	13.80	-0.52
F	8.07	0.48	5.13	0.16	14.56	0.25
G	8.40	1.51	4.35	-0.44	14.13	-0.19
H	7.52	-1.22	3.97	-0.74	14.17	-0.15
I	-	-	1.51	-2.66	-	-
J	7.91	-0.04	5.24	0.30	14.00	-0.32
K	7.75	-0.49	3.77	-0.85	-	-
L	7.62	-0.91	5.10	0.14	14.10	-0.22
M	-	-	5.00	0.06	13.50	-0.83
N	7.40	-1.60	7.50	2.01	17.10	2.84
P	8.36	1.38	5.43	0.40	15.01	0.71

Smoothness, pH, and Moisture Content:

Smoothness varied widely, from 105 to 175 ml/min, with Lab G performing the best (175 ml/min, Z-score 1.87), while Lab D reported the lowest (105 ml/min, Z-score -1.39). pH values ranged from 7.40 to 8.40, with Lab G having the highest pH (8.40, Z-score 1.51). Lab N had the lowest pH at 7.40 (Z-score -1.60).

Moisture content was relatively stable across labs, ranging between 5.0% to 7.5%. Lab N was an outlier with a Z-score of 2.01, showing the highest moisture content.

***Ash Content*:**

Ash content results displayed notable variability. Lab N showed a significantly higher ash content (17.10%) with a Z-score of 2.84, while most other labs reported values around 13.0%-14.5%, with Lab H and others reporting lower Z-scores.

The results show that while most labs performed consistently, certain outliers such as Labs N, G, and D performed significantly differently in parameters like moisture, smoothness, and double fold, respectively. Z-scores serve as an effective measure to gauge inter-lab precision and accuracy across the assessed parameters.

RECOMMENDATIONS FOR IMPROVEMENT:

Based on the findings of this ILC programe, several recommendations can be made to improve the proficiency and reliability of testing laboratories:

a) Standardized Testing Protocols: Encourage all laboratories to adopt more consistent and harmonized testing procedures for parameters like brightness, tensile index, opacity, and smoothness to reduce variability in results. This can be achieved through adherence to ISO/IEC 17025 standards and regular proficiency testing.
b) Enhanced Calibration of Instruments: Differences in opacity and double fold values indicate possible discrepancies in instrument calibration. Laboratories should ensure frequent recalibration of equipment to align with national or international standards.
c) Training and Certification: Ensure that lab personnel are uniformly trained in handling paper-testing equipment and interpreting results. Certification programs could ensure that operators maintain consistency in methodologies.
d) Data Sharing and Collaboration: An inter-laboratory data-sharing platform can help identify trends in discrepancies and areas for improvement, driving innovation and consistency in testing methods across the paper industry.

IMPLICATIONS FOR THE PAPER INDUSTRY

a) Quality Control: The insights gained from ILC can help manufacturers maintain tighter control over product quality, leading to more reliable and standardized paper properties.
b) Cost Efficiency: Reducing variability across laboratories can help the industry minimize wastage and errors in paper production, leading to more cost-effective operations.
c) Sustainability: Standardized processes and high-quality materials can contribute to more sustainable production practices by reducing waste in paper production cycles.

CONCLUSION

The Inter-Laboratory Comparison (ILC) for 80 GSM SS Maplitho paper revealed critical insights into the consistency and reliability of testing procedures across participating laboratories. Evaluating 12 key parameters, including grammage, thickness, tensile index, and brightness, the study aimed to enhance confidence in laboratory results within the paper industry. The analysis highlighted significant variability among the results, particularly in brightness and opacity measurements. This inconsistency suggests the need for standardized testing protocols to ensure uniformity across laboratories. Furthermore, discrepancies in tensile and tear index values point to potential issues in instrument calibration and methodological differences. Regular calibration and adherence to international standards are essential to mitigate these variations. Moreover, the findings underscore the importance of comprehensive training for laboratory personnel. By enhancing training programs focused on testing methodologies and data interpretation, laboratories can improve accuracy and reliability in their results. In conclusion, while the ILC has provided valuable benchmarks for laboratory performance, it has also identified areas requiring improvement. Implementing standardized protocols, enhancing training, and ensuring regular calibration can significantly improve product quality in the paper industry, fostering greater trust and competitiveness in the market.

Acknowledgment

The RPPT Laboratory of NTH (NR) expresses gratitude to the Scientist In charge, National Test House for his valuable support and continued encouragement. We express our gratitude to all participating laboratories for joining the scheme.

Availability of data and materials

The data supporting the findings of this study are not publicly available to protect the privacy of laboratory participants. Requests for access to the data may be considered on a case-by-case basis, subject to approval by the relevant competent authority.

Conflicts of Interest: The authors declare no conflicts of interest.

Funding: None.

Contribution: Corresponding author organized the ILC program and write the manuscript.

Abbreviations

ILC-Inter Laboratory Comparison
SS - Surface Sized
GSM - Grams per Square Meter
ISO - International Organization for Standardization
pH - Potential of Hydrogen
Cobb - Referring to the Cobb test for water absorbency

REFERENCES

[1] IS 1060: Part 5: Sec 5: 2021 (ISO 536:2019), Methods of Sampling and Test for Paper and Allied Products Part 5 Methods of Test for Paper and Board Section 5 Determination of grammage
[2] IS 1060: Part 5: Sec 3: 2014 (ISO 534: 2011), Methods of Sampling and Test for Paper and Allied Products Part 5 Methods of Test for Paper and Board Section 3 Determination of Thickness
[3] IS 1060: Part 5: Sec 6: 2014 (ISO 1924-2: 2008), Methods of Sampling and Test for Paper and Allied Products Part 5 Methods of Test for Paper and Board Section 6 Determination of tensile properties-Constant rate of elongation method (20 mm/min)

[4] IS 1060: Part 6: Sec 1: 2014 (ISO 1974: 2012), Methods of Sampling and Test for Paper and Allied Products Part 6 Methods of Test for Paper Section 1 Determination of tearing resistance - Elmendorf method
[5] IS 1060: Part 4: Sec 13: 2020 (ISO 2470-1: 2016), Methods of Sampling and Test for Paper and Allied Products Part 4 Methods of Test for Paper, Board and Pulps Section 13 Measurement of diffuse blue reflectance factor — Indoor daylight conditions (ISO brightness)
[6] IS/ISO 2471: 2008 (ISO 2471: 2008), Paper and Board — Determination of Opacity (Paper Backing) — Diffuse Reflectance Method
[7] IS 1060: Part 5: Sec 4: 2014 (ISO 535: 1991), Methods of Sampling and Test for Paper and Allied Products Part 5 Methods of Test for Paper and Board Section 4 Determination of water absorptiveness - Cobb method
[8] IS 1060: Part 6: Sec 3: 2015 (ISO 5626: 1993), Methods of Sampling and Test for Paper and Allied Products Part 6 Methods of Test for Paper and Board Section 3 Determination of Folding Endurance of Paper
[9] IS 9894: 1981, Method of Test for Smoothness/Roughness of Paper
[10] IS 1060: Part 4: Sec 7: 2024 (ISO 6588-2: 2021), Methods of Sampling and Test for Paper and Allied Products - Part 4 Methods of Test for Paper, Board and Pulp - Section 7 Determination of pH of Aqueous Extracts-Hot Extraction Method
[11] IS 1060: Part 5: Sec 2: 2021 (ISO 287:2017), Methods of Sampling and Test for Paper and Allied Products Part 5 Methods of Test for Paper and Board Section 2 Determination of moisture content of a lot Oven-drying method
[12] IS 1060: Part 4: Sec 3: 2018 (ISO 2144: 2015), Methods of Sampling and Test for Paper and Allied Products Part 4 Methods of Test for Paper, Board and Pulps Section 3 Determination of Residue (ash) on ignition at 900°C.

****